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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

JANUARY 16.

Institute of Fuel:—Ordinary meeting in London. "Continental Experience in Pulverised Fuel Practice," Paper by Mr. Berg and Mr. Erich Vogt, of Cologne.

JANUARY 17.

Co-Ordinating Committee:—Joint meeting at Birmingham. "Refractories," Paper by A. J. Dale.

JANUARY 18.

Institution of Chemical Engineers:—A Public Lecture in London by Professor John W. Cobb, C.B.E., B.Sc., F.I.C., on "The Reactivities of Solid Carbon in Fuel Processes."

Institute of British Foundrymen.

JANUARY 12.

Wales and Monmouth Branch:—Ordinary meeting at Newport. "Making Patterns to Expedite Output," Paper by Ivor Rees.

Birmingham Branch (Junior Section):—Ordinary meeting at Birmingham. "Mixing and Melting Pig-iron," Paper by F. J. Cook.

Lancashire Branch (Junior Section):—Short Paper Competition.

Scottish Branch (Falkirk Section):—Ordinary meeting at Falkirk. "Foundry Costing," J. G. Smeddon.

JANUARY 17.

Scottish Branch (Paisley Section):—"Symposium on Apprentice Training."

JANUARY 18.

Sheffield Branch:—Annual dinner at Sheffield.

Middlesbrough Branch:—Presidential address by S. V. Tay.

More Patent Reform Proposals.

A report has just been issued by a Committee of the British Science Guild, the personnel of which will, we think, command very general respect, on the reform of the patent law, and its recommendations will appeal to all who have met difficulty in applying patent law evolved for past conditions to present circumstances.

The suggestions are grouped, and in a section dealing with novelty we again meet the idea that the British Patent Office search should include documents other than prior British specifications. This type of search alone will give our inventors and capitalists as much faith in the validity of patents as exists in German and American patents. To limit the area of search it is proposed that no patent should be invalidated by a prior publication more than fifty years older than itself. No statement or publication by a patentee, it is suggested, should preclude him from taking out a patent later; that is, no inventor should have his own anticipations cited against him.

In a particularly important section it is urged that the demand of the Patent Acts for "subject matter" should have regard to the meritorious part of systematic research in promoting industrial progress. The relation of science (*i.e.*, discovery) to invention is discussed in an able appendix to the report, in which it is pointed out that while inventions are brain-waves, scientific developments are inevitable in the sense that many properly-trained scientific men, given the means and opportunity of studying the same problem, would arrive at the same conclusion. That is, inventive ingenuity and scientific solution are different in their method of approach. It hampers a scientific worker wanting to patent a useful idea to be compelled to show "inventive ingenuity." At one time invention was the only way in which industry progressed. To-day it is not, and a patent system, which is admittedly required to encourage industry, is lacking if it continues to develop solely on the lines of demanding subject matter, novelty and utility. What subject matter can characterise an idea, or what novelty can arise when any one of a hundred men could get at the result if they had had occasion to work at it? Then the existing plan of giving priority to the first man, good in a patent, is unjust in scientific discoveries which are only often separated in different countries by days.

Another important recommendation is that a short-term patent, granted quickly and cheaply, should be introduced to cover the field in between a registered design and a full and somewhat costly patent. Thus a new type of ladle might well be worth more than the poor protection of the registered design, and not worth the cost of a full patent, especially as it is necessary to get it on the market at once.

The old grievance of the Chancellor of the Exchequer using the Patent Office surplus, provided by inventors, is also raised again. This is of the order of £100,000 per annum. Yet a complete Empire Patent, to say nothing of foreign patents, costs the inventor something like £1,500 for the full term of years.

Preparing for the X-Ray Attack.

A perusal of recent issues of the JOURNAL is more than sufficient to convince every ironfounder that he knows virtually nothing of metallurgical control, except the roll founder, the Diesel-engine cylinder maker, and (though he has not been mentioned) we think we might add the automobile founder. Unfortunately, readers are merely informed that they should institute a system of control for their sand and metal! Apparently we are expected to know just how to accomplish this, but the truth of the matter is that a variation in procedure has to be made for each size of foundry. For the very smallest, the system outlined by Mr. Robert Shaw in his lecturette to the Newcastle Section of the Institute of British Foundrymen is in every way adequate so far as the metal is concerned, whilst a reference to Mr. J. E. Fletcher's work will put them in the way of controlling sand. For medium-sized establishments, a young metallurgist should be employed, who would use the various laboratories catering for the industry whilst assisting the management in every way possible. For the largest establishments, the metallurgist should be provided with a staff and adequate tools for his workshops, *i.e.*, laboratories.

We agree with Mr. Young as to the desirability of adequate specifications of compositions for various jobs, as it would indirectly create metallurgical control in large sections of the industry. We have, on previous occasions, pointed out that the institution of a standard is the recognition of a lull in progress, but it certainly does represent progress. It cannot, however, denote the actual worth of a casting, even though the average strength of the average section of the piece is made available. Recently X-rays have indicated what we stated many years ago that the *perfect* casting had yet to be made. On that occasion we insisted that if one continued smashing up a casting one would eventually find some sort of flaw. We now wish to qualify that statement by excepting the best centrifugally-made castings. This may appear very discouraging, but founders—both iron and steel—can take heart in the fact that all wrought material is not perfect—it may suffer from seams, ghosts, cavities and a host of other defects.

The problems which the foundry trade will have to face in the future when making high-grade work will be materially nearer solution if its various units can satisfy themselves that they are invariably filling the moulds with suitable metal, and thus completely eliminating one important variable.

XUM

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Chemist or Foundry Engineer.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—May I congratulate you on the attitude outlined in your leading article under the heading "Chemist or Foundry Engineer?" in your issue of January 3? I do not for one moment wish to belittle the work or status of the chemist—there are many splendid workers whose arena is the laboratory just as there are highly valuable medical men who specialise in, say, biology—but for routine foundry practice it is surely a mistake to install an official whose function is the chemical analysis of materials, and expect him, in addition to exercising that very delicate and absorbing occupation, to co-operate with a foreman who is mainly concerned with his own administrative and practical duties, and cannot be expected to undertake the studying and interpretation of chemical results, a task for which years of special training and study are required.

It is quite true that even under such conditions chemical analysis is worth its place, if only as a check on the composition of materials and product, but nothing like full value can be given for the expenditure incurred, and I will venture to suggest that much of the current misunderstanding as between the "chemical" and "practical" points of view is due to situations of this sort.

I submit that the proper course is to install in the foundry a metallurgist who is trained in the properties, structures, treatment and technology generally of the product being handled as well as in that of foundry processes, and who by experience is able to appreciate the practical point of view, linking with it the results of research and local analysis.

Whether the metallurgist is to be given a laboratory and chemical assistance or whether he is to send his samples out for analysis is a question to be decided on local considerations in each case, but it is the metallurgist and not the chemist who forms the liaison officer between science and shop practice, and who should be the essential figure. I would stress the fact that chemical analysis is only one of several methods used by the metallurgist in keeping under observation the process at which he is assisting.

Those duties upon which you touched, such as helping the foreman to handle special charges, etc., etc., form a further claim upon his attention, and one may summarise matters by saying that whereas the chemist's activities focus in the laboratory, those of the metallurgist focus in the foundry. I would add that if I were organising the metallurgical services for a foundry of moderate means I should be inclined, subject to circumstances, to ask for a microscope in the first place, sending selected samples out for analysis until such time as the cost of a laboratory was clearly justified.—Yours, etc.,

F. D. CORBIN.

Waster Castings: Their Lesson and Prevention.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—With reference to this article which appeared in your issue of December 13, 1928, I think it is unfortunate that the author, Mr. McRae-Smith, did not confine his observations within the title of the heading, and it is very unfair and unwise to enunciate a waster percentage for any specific class of casting, ranging from zero to 3 per cent., then to naively claim an allowance of 10 per cent. for one's own particular class of work.

Where there is an active and intelligent metallurgist; where the moulders are competent craftsmen; (and one expects) the plant and the organisation to be in keeping, 10 per cent. is extremely high, however important the work.

A more important factor, and of serious moment these days, is, What is the cost of production? Many foundries, especially jobbing shops (still the cradle and backbone of the trade), on first-class work, have a higher waster percentage than Mr. McRae-Smith allows, yet the cost of production in many of the large engineering combine shops is as 1 to 6 i nfavour of the jobbing shop.

In some foundries I have known, time is no object (providing, of course, the men don't loaf about), materials (quality or quantity), auxiliary labour, power, clerical staff and paper, each and all of little consequence if the result is satisfactory. Once a moulder has been for any length of time in some of these foundries, he is unemployable in the general foundry, large or small, producing jobbing castings for the trade.

All foundries produce waster castings, and whatever the class of work, either extremely high or extremely low, the average is about the same, for (only in exceptional cases) the plant and organisation is in keeping with the class of work produced, with this advantage: Where there is a resident metallurgist all materials tend to be of better quality, either necessarily or unnecessarily. Again I repeat 10 per cent. is extremely high where there is a first-class organisation, but before we lay down any law on waster averages let us first consider the cost of production. This is then fair to all concerned.—Yours, etc.,

January 4, 1929. W. J. COOPER.

Belper Foundry Changes Hands.

Important developments are foreshadowed in the engineering industry of Derbyshire, and all round employment during the present year should be better than in 1928.

Recently there have been one or two big amalgamations, and our representative now learns that the Park Foundry, on Derby Road, Belper, has been taken over by a new company. In the past the Park Foundry Company, which employs about 200 hands, have specially devoted their attention to the production of stoves and grates. The concern, however, has now been acquired by a London firm of ironfounders, not a combine, and it is hoped that under the new management the standard and quality of the products will not only be maintained, but enhanced. It is understood that the company will still continue to trade as the Park Foundry Company. During the past four years consistent and steady progress has been maintained in spite of the difficulties of the industry generally. The premises, which are situate just off the main road, are extensive, and there is plenty of space for the development of the buildings.

A FOUNDRY TRADE JOURNAL representative, who made inquiries, was informed that at present it was not possible to say whether or not the number of workmen would be increased. It is, however, quite definite that no reductions will be made, and there is every prospect of big developments in the course of the next few months. No definite proposals of the new company are at present available.

Charitable Contributions.

The following contributions to infirmaries and other benevolent institutions in Scotland have just been announced:—

	£	s.	d.
The employees of Messrs. Steven & Struthers, Limited, Anderston Brass Foundry, Glasgow	86	0	0
The employees of the Clyde Structural Iron Works, Scotstoun ...	67	0	0
Employees of Messrs. Drysdale & Company, Limited, Yoker	261	0	0
Employees of Glenboig Union Fireclay Company, Limited	164	0	0
Employees of Rivet, Nut and Bolt Company, Limited, Glasgow ...	539	7	7
Employees of Messrs. Jones & Campbell, Torwood Foundry, Larbert	206	0	0

GEORGE LARGE, aged 17, an apprentice moulder at the L.M.S. works, Derby, was admitted to the Derbyshire Royal Infirmary on January 3 suffering from injuries to the leg. When breaking up a casting a piece of metal flew out and struck him.

Random Shots.

OUR SOCIETY GOSSIP COLUMN.

The recherché little luncheon as a preliminary to important pourings is growing in popularity. At one of the most enjoyable that I attended last week, the cocktails, I noted with interest, were served in buckets. Will this innovation become the custom in fashionable circles I wonder?

* * *

I *hear* that the latest move under the auspices of the Brighter Foundries Association is the introduction of daily cabaret performances in the shops, to be provided voluntarily by the lady members of the Coicadero cabaret company. This brilliant suggestion, they tell me, originated with that charming woman, Mrs. Frederick Boggs, whose husband is one of the most esteemed foremen in the industry.

* * *

Everyone is talking of the latest example of affectionate devotion provided by the apprentices at the Mud and Muddle Foundry this week. They have subscribed to present the foundry manager with a handsome birthday gift in the shape of a specially powerful megaphone, specially fitted with electrical amplifiers. One of them told me that they felt it a shame that Mr. Noggs' brilliant oratory and fluent command of language should not reach every corner of the works.

* *

There is a certain type of humorous story which is said to be told as a test for a sense of humour, and I must confess that I have come to the conclusion that I am sadly lacking in a humorous sense. One such story, for example, is the one about a horse pulling a heavy cart full of hay up a hill. Suddenly it stopped, and said to the carter: "This is far too heavy for me. I am not going an inch farther!"

* * *

The carter stared at the horse, scratched his head, and ejaculated: "Blimey, that's the first time I ever heard a horse talk!" At that moment an Aberdeen terrier, hidden in the hay, poked out its head, and said: "Me, too!"

* * *

There is no prize offered for anybody who can see the joke, but I should really be glad to know where it is!

* * *

A big-game hunter was walking in tiger country, alone and without his gun. Suddenly a great man-eating tiger, famous amongst hunters for its torn ear, approached him. The hunter gave himself up for dead. The tiger crouched, sprang, missed him by a few feet, turned round, looked regretfully at him, and loped off into the jungle.

* * *

The hunter rushed back to the camp, the signal was given, and twenty white hunters and five hundred beaters were soon following the spoor. At last they surrounded the man-eater in the worst part of the jungle. There he was, hideous and ferocious.

* * *

What was he doing? I will tell you. He was practising low jumps among the branches.

* * *

Mr. Walter Jerrold tells the following:—"Johnny," said the nurse, "you mustn't use that dreadful word." "Why?" replied the small boy scornfully. "Shaw and Masefield use it." "Well, then, you mustn't play with such naughty boys."

The first casualty reported to an inspector under the new Order was an apprentice moulder's Christmas watch chain. The accident occurred through his mistaking a locomotive whistle for the knocking-off buzzer.

MARKSMAN.

Metallurgy of Steel Castings.

By A. Mc Cance, D.Sc.

(*Continued from page 466.*)

The only way in which this contraction can be avoided is to taper the ingot instead of having it parallel. Obviously, since the metal is solidifying in parallel sheets to the outside surface, if a section is tapered it will still solidify parallel, but the contraction space left will be reduced. The amount of taper that is required varies, of course, according to the dimensions of the article in question, but there is a general rule which the author has devised which can be expressed in a curve which gives the amount by which the pipe is raised by differing degrees of taper (Fig. 7). That curve shows how taper reduces the percentage pipe.

The next question which arises is: How does the composition and properties of the metal affect this ability to feed and so prevent those contraction cavities, and to explain that it is necessary to consider what is generally known as a typical freezing diagram (Fig. 8). In the case of pure iron with the melting point as shown, the amount of the added element is increased, as shown in Fig. 8. It will be obvious that the object of the head being to keep a portion of the casting liquid as long as possible, the longer the time taken from the commencement to the end of the freezing, the better chance it has of feeding, and so it is necessary to know how this freezing range is affected by changes in composition. It can be taken that for any given carbon content this range is mainly affected by the percentage of phosphorus, sulphur and oxygen, while manganese and silicon affect it hardly at all, and so the behaviour of steel made by various processes is really shown up by their content of impurities. In Table I are given

TABLE I.

Process.	Electric furnace	Acid OH	Bessemer.
Sulphur ..	0.020	0.045	0.060
Phosphorus..	0.020	0.040	0.055
Oxygen ..	0.025	0.040	0.080
Total ..	0.065	0.125	0.195

some approximate figures which may be taken as average. From this diagram it will be noted that those impurity contents do indicate the properties of the various steels from the steel founder's point of view. It is well known that electric furnace steel is difficult to feed, whereas, on the other hand, Tropenas steel feeds much more readily, and consequently the heads do not require to be so large. There is another factor which is affected by the impurity content, and that is what might be termed the fluidity; that is, fluidity as distinct from viscosity. The viscosity of a liquid is the internal friction which it possesses against movement at a constant temperature. In the case of steel foundry work, what is required is fluidity; that is, the ability to run a given length under cooling conditions, and it will be observed that as that freezing range increases the ability to run a certain distance before solidification is complete under given cooling conditions will depend on the length of that freezing range, and consequently on the content of impurities. Therefore, electric furnace steel as against Tropenas steel, will not run so well; it will be stickier, while acid open-hearth steel occupies an intermediate position. The content of impurities, therefore, in those steels is of very great importance, and it is unfortunate that just those factors which give a good steel from the steel-founder's point of view have other disadvantages when it comes to mechanical properties.

Cooling Contraction.

The mass of metal being entirely solid at a temperature just immediately below the freezing point, and it has to cool down to ordinary temperatures, most metals show a perfectly smooth contraction curve as they cool down from a high temperature to a low temperature, but here again steel is an exception, and it does not contract uniformly. Owing to the presence of the change point, there are abrupt changes in contraction as it is cooling down. Fig. 9 outlines the expansion of pure iron. The change which is taking place in the neighbourhood of 1,400 deg. C. is of a very awkward nature. The casting is held in the sand, which is heating up in contact with the casting, while at the same time the metal is cooling down. The two effects, therefore, are antagonistic, and on reaching a temperature of 1,400 deg. C. there is this abrupt contraction which must throw an added strain on the metal, which it may or may not resist. Here the art of the foundryman again enters if the consequences of this abrupt expansion and contraction are to be obviated. The total contraction of the steel left to itself, proceeding from the melting point down to ordinary temperature, is approximately 2.4

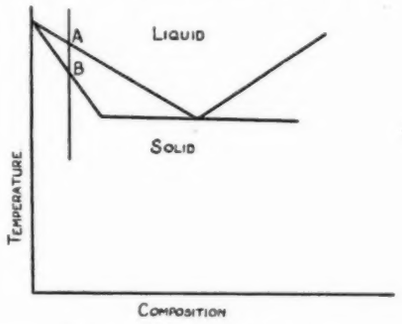


FIG. 8.—FREEZING DIAGRAM.

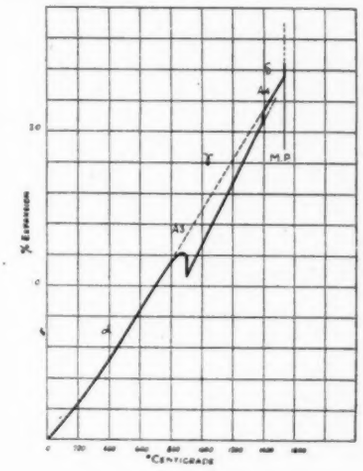


FIG. 9.

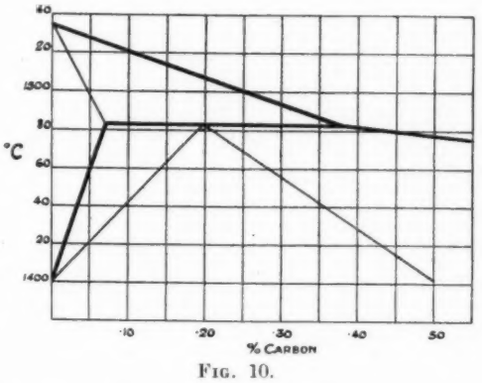


FIG. 10.

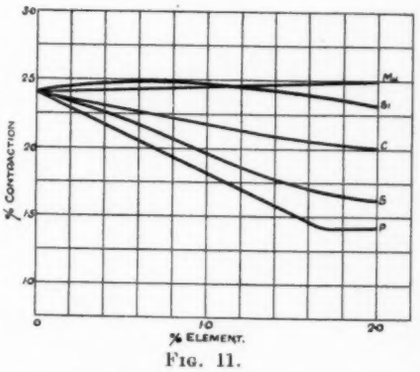


FIG. 11.

per cent. The patternmaker allows a figure of approximately 1.6 per cent., so that there is 0.8 per cent. in ordinary practice which has to be taken up by the stretch of the metal, and in complicated castings even the 1.6 per cent. allowance for the pattern disappears altogether and no pattern allowance has to be made, which means that the whole of the contraction, amounting to roughly 2.4 per cent., has to be taken up by the stretch of the metal. If the metal can adequately deal with that contraction everything is well, and the casting comes out whole. If, on the other hand, it cannot deal with it, then it has to give way and tear in some place, and in complicated castings this is one of the most difficult features to avoid, especially in a thin casting, because the ratio of the area of metal to the surrounding mass of sand is all against the casting withstanding its own cooling stresses.

What we have been considering is the case of pure iron, but a diagram can be evolved to show how that abrupt contraction varies, or how the delta point, as it is called, varies with content of carbon. (Fig. 10.) This diagram indicates how the change point which takes place at 1,400 deg. C. varies with the carbon, and it will be noted that the temperature at which it takes place rises appreciably with the small content of carbon, until it joins up with the main freezing line, when the contraction disappears altogether. Carbon therefore minimises and diminishes the effects of this contraction, although the variation of this contraction with composition is, unfortunately, not very great. (Fig. 11.) Table II shows the total contraction in a bar which is perfectly free to move in the sand. Many experiments have been recently carried out to find how this cooling contraction varies with different conditions of casting and of moulding. Fig. 12 shows some of the results of Korber and Schnitzkowski. These were obtained by Korber and Schnitzkowski, and the method they employed was to cast plain or flanged bars in green-sand and dry-sand moulds and to measure by means of a suitable instrument the variation in the length of the bar as it cooled, the temperature also being observed separately. In the figure, the numbers refer to the diameter of the bar, used in the experiment, and the vertical scale gives the percentage contraction in length. The total contraction which was obtained, even with the bar cast freely in green-sand, only averaged 2.2 per cent., irrespective of the diameter of the bar. It takes place in practically two equal portions. The portion of immediate interest is that which takes place before the metal really cools, and consequently takes place at a temperature when the iron is weak and least able to stand it. The ability of the steel to withstand this contraction will depend

TABLE II.—*Contraction of Plain Round Bars (Korber and Schnitzkowski).*

Dia. m/m.	Temp. of casting. Deg. C.	Total contraction Per cent.	Contraction to AR_3.	Contraction after AR_3.
20	1,480	2.20	1.19	1.01
30	1,460	2.18	1.21	0.97
40	1,450	2.13	1.06	1.07
50	1,490	2.16	1.20	0.96

upon its strength, therefore under ordinary conditions it is independent of the dimensions.

Considering the case (Fig. 13 and Table III) of a small bar with a big flange at the end, it will

Table III.—(*Korber and Schnitzkowski*).

Dia. m/m.	Temp. of casting. Deg. C.	Contraction total Per cent.	Before AR_2	After AR_2	Mould.
20	1,470	2.03	1.01	1.02	Green.
	1,460	0.34	0.21	0.13	Dry.
30	1,500	2.13	1.12	1.01	G.
	1,470	0.61	0.18	0.43	D.
40	1,480	2.07	1.06	1.01	G.
	1,460	0.89	0.41	0.48	D.
50	1,470	2.19	1.18	1.01	G.
	1,490	1.78	0.89	0.89	D.

be seen that in the dry-sand mould hardly any contraction took place at all, only about 0.3 per cent., whereas in the green-sand mould, even with the flanges, practically the full contraction occurred. With larger diameter bars (Fig. 14) there is not such a great difference, although even here there is

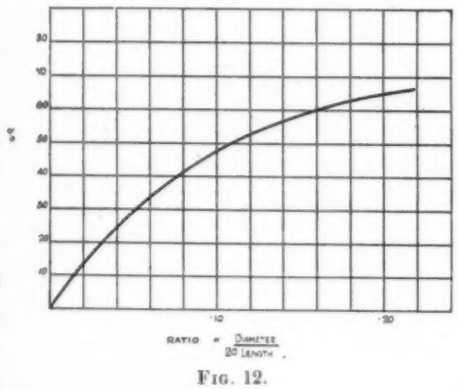


Fig. 12.

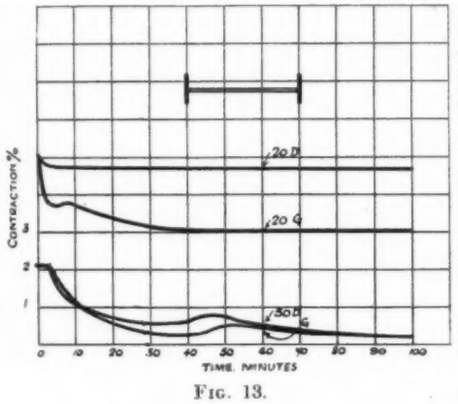


Fig. 13.

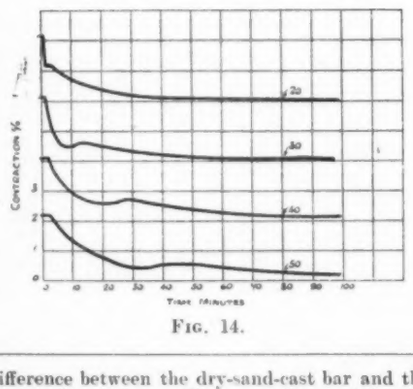


Fig. 14.

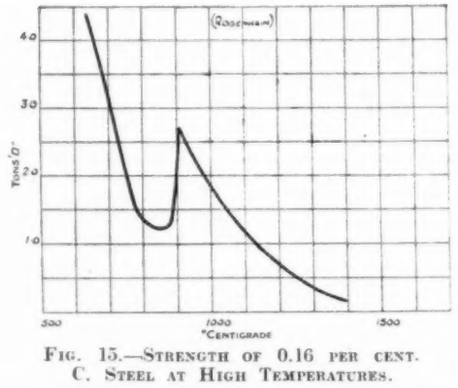


Fig. 15.—Strength of 0.16 per cent. C. Steel at High Temperatures.

a difference between the dry-sand-cast bar and the green-sand-cast bar. These results explain the great difficulty there is in casting thin sections, when the contraction which follows after the cooling is not allowed to take place. The contraction occurring at the higher temperatures is of by far the greatest importance, and it is interesting to examine the strength of the steel at such temperatures to ascertain what chance it has of resisting.

Fig. 15 gives the tensile strength of mild steel as the temperature is increased, from which it will be noted that it falls very rapidly until in the neighbourhood of the change point, when it rises, and then falls rapidly again. In the neighbourhood of 1,000 deg. C. the strength is less than 2 tons per sq. in.; in the neighbourhood of 1,300 deg. C. it is less than ½ ton per sq. in., so that in this region, which is the danger zone when metal is cooling down (from 1,500 deg. C. to approximately 1,300 deg. C.), the steel has only a strength of approximately ¼ to ½ ton per sq. in. to resist any stress which is produced by the cooling. When this is realised it is surprising that any castings strip whole at all. The author well remembers a casting with which he had difficulty, where the thickness was approximately 1¼ in., and unless the core irons were broken within four minutes after casting tearing took place, showing that the real danger zone so far as hot tears are concerned is in that region immediately below the freezing point down to approximately 1,200 or 1,300 deg. C.

Since the composition affects the total contraction very little one can consider what effect the composition has in resisting those strains, and here one cannot hope for very much assistance, because the increase in strength which the moderate quantities of alloy it is possible to add, give to the steel is inappreciable. There is one detrimental element, however, and that is sulphur. The ability to tear readily is greatly enhanced by a high sulphur content. This, however, is a very complicated question, since the oxygen content is also concerned in it as well.

The difficulties which are produced by the physical actions described, and which have to be allowed for, have to be wholly overcome by the art of the founder. The physical laws are there definitely; they cannot be removed, they have to be circumvented, and it is this which makes the art of steel founding so very difficult, because each individual casting has to be separately considered.

The steel founder has no choice in the physical properties of his metal, but the designer always has some choice in the manner of carrying out his designs. Therefore the designer should consult with the steel founder in the early stages of the design, and not merely after the design is completed, if the best results are to be obtained and satisfactory castings are to be made. Steel castings should be designed *as* steel castings, and not used as one sometimes imagines they are, judging from some blueprints, as a means of developing a love for the fantastic in a drawing-office staff. If the steel founder and designer get together more they will certainly produce a "production job"; that is, a job that will give the maximum amount of satisfaction with the minimum amount of loss and failure to all concerned.

Important Steel Combine.

The proposed fusion of Vickers-Armstrong, Cammell Laird and Vickers, Limited, involves Nottingham, as the firm of Messrs. Cammell Laird have a large foundry and engineering works in the city, which, in normal times employs a great number of foundrymen.

It is thought that, when the three firms combine, Nottingham may be seriously affected, and that orders which have been sent to this branch may go elsewhere. This, however, is not likely to happen, and at any rate the employees can for the time being rest contented. Like most other foundries that of Messrs. Cammell Laird has had quite its full share of depression during recent years, but there have, however, been sufficient orders to keep the men employed, and when larger contracts have been secured the management have been able to increase the number of its workers.

The works were originally constructed by the Government during the war for the purpose of the manufacturing munitions. The firm acquired the premises on the conclusion of the war for the purpose of constructing steel railway carriages and wagons. The factory, which has been enlarged, and covers an area of about 12½ acres, finds work, in normal conditions, for about 1,500 people. During the past few years important contracts for the supply of steel coaches for the Indian State Railway and Bombay, Barode and Central Indian Railway, and wagons for the Burma Railway Company, the Central Argentine Railway the Birkaner State Railway, and other foreign railways, have been executed, in addition to contracts for the railway companies of England. An extensive business in the "Sentinel-Cammell" steam rail-coach, which is built in conjunction with the Sentinel Wagon Works, Limited, has always been developed, and examples are now running in many countries. Last year a number of the cars were delivered to British railways and to railways in India, Ceylon, South America and elsewhere.

Although Messrs. Cammell's Nottingham works are not overcrowded with orders at the present time, there is sufficient to keep the men employed, and last week excellent news was received with regard to an important railway contract from abroad in which the firm will receive its fair share. The contract, which is for a 600 40-ton drop sided all-steel bogie wagons, has been awarded to Cammell Laird & Company, Limited, on a tender of £255,600. An order for 400 high-sided all-steel bogie wagons of similar capacity for the same railway is expected to be placed at an early date. From among six tenders—five British, and one from the U.S.A.—that of the Metropolitan Carriage, Wagon & Finance Company, Limited, has been accepted for the supply at a cost of £96,000 of thirty main-line saloon cars for the Union of South Africa Railways. The engine units, shells and steel work, etc., are to be manufactured at Shrewsbury and the Nottingham works of Cammell Laird, respectively.

During recent years a scheme has been promoted by the officials of this firm whereby the poor mothers and children living in that part of the city, where the works are situate, are entertained to a Christmas party. This year the necessary funds have again been raised and the party is to be held in the mess-room at the works in King's Meadow Road.

Long Services Recognised.

On the completion of fifty years' service with Messrs. William Baird & Company, Limited, Ironmasters, Mr. Andrew Pringle, Muirkirk, has been the recipient of gifts from the firm and others. Mrs. Pringle also received a number of gifts.

A presentation was recently made at Derby to Mr. F. Perman, in recognition of his long services with the L.M.S. He has decided to retire after spending forty-eight years with the company, thirty-six of which he served in the engineers' department. A prsentation has also ben made to Mr. D. S. Kay, President of the Derby Students' Association, on his retirement from the headmastership of the Abbey Street schools. Mr. Kay has built up a school of commerce which has proved itself of great value to the engineering and allied industries.

Shrinkage Holes in Small Grey Iron Castings.

The December meeting of the West Riding of Yorkshire Branch of the Institute of British Foundrymen, on December 1, was of a more ambitious character than usual. The proceedings occupied both afternoon and evening, with tea as guests of the Branch-President (Mr. W. G. Thornton, of Bradford). By kind permission of Principal H. Richardson, M.Sc., head of the Bradford Municipal Technical College, the members assembled there at 3 p.m., and had the privilege of a most interesting afternoon's tour of the many departments of that remarkably well-equipped educational institution.

The members found much of interest among the many forms of casting used in machinery in the engineering, textile, chemistry and dyeing and other departments of the College.

The party had tea together in the College Refectory. The President of the Institute (Mr. S. H. Russell, of Leicester) was present, along with Mr. P. A. Russell, B.Sc., his brother, who was present to give the evening's paper.

Address by Mr. S. H. Russell.

At the business meeting Mr. S. H. Russell, making the meeting his official presidential visit to the Branch, addressed the assembly, remarking that no doubt many members were sometimes inclined to think the President had a happy and pleasant job in being invited to social functions of Branches, and that all he had to do was to make a pretty speech. (Laughter.) Whilst one fully appreciated those invitations, he was not quite sure such occasions were quite the best thing for the Institute or for the President himself, because the whole atmosphere at a social function was quite different from that at an ordinary business meeting. In visiting the West Yorkshire Branch that day he had had the benefit of a little happy social intercourse over tea, and of great interest in the works visit, but he had also had the very great advantage of being present at an ordinary business meeting of the Branch Council, and now he was looking forward with interest to the ordinary business meeting of the general members, at which, from his knowledge of the West Yorkshire Branch, he was quite sure he would hear an excellent discussion following the Paper to be given. His attendance at the Branch Council meeting had given him a useful insight into how the Branch business was conducted and had impressed upon him something of the difficulties which one Branch, as distinct from other Branches of the Institute, was up against. He must admit that he had always regarded his own Branch in the East Midlands as being one very difficult to conduct because of geographical distribution of the membership, but he was inclined to think now that in that respect the West Yorkshire Branch had perhaps even greater difficulty. It was one thing to look at a map and see a network of railways in West Yorkshire, and quite another to come into West Yorkshire and learn at first hand of the wide sphere of foundry activity covered by the Branch and the awkward journeys many of the members had in getting to and from some of the meetings. The Branch had undoubtedly had a difficult task in selecting the most generally convenient centre, but he thought the choice of the Bradford Technical College was probably the most widely acceptable one having in mind the geographical distribution of the bulk of the membership. The Branch was certainly to be congratulated on such an excellent attendance as was present that day. On the previous day, the President mentioned, he had had a most interesting day in the Keighley district, and, thanks to the assistance of one of the most active members of the Branch, he had seen much of interest.

There was no doubt, proceeded the President, that the success of the Institute of British Foundrymen depended greatly on the success of the Branches. He could not imagine the Institute could flourish very long if it had no more than the annual conference—despite the interesting Papers given there, some of which were perhaps inclined to be rather too technical for a good many rank and file members—and the valuable social gatherings arranged in connection therewith. The success of the Institute depended on the success of the Branches. And the success of the Branches depended on two main factors: Firstly, the enthusiasm of their officers, and in West Yorkshire Branch they were very fortunate in that respect—having a President who was prepared to go deep into his pocket as well as give much of his time and effort for the Branch; a secretary who was one of the keenest enthusiasts in the whole of the Institute and one of its most consistent workers; and men who were rendering most valuable work on the Institute's Council as well as to the Branch. The second essential to the success of a Branch was good attendance and support by the members at the meetings. Sometimes, as an excuse for absence from meetings, it was remarked that one could read the Papers just as well in the JOURNAL as going to hear them given, but Mr. Russell suggested there was a very great difference between reading a Paper in cold print and reading it in the JOURNAL after having heard it given by the author, with the advantages of the personal touch, the little interesting and informative asides on detail, the subsequent questions and the discussion. The man who gave a Paper was usually none too sure of his own ground—(laughter)—and was hoping always for new points to be raised in discussion or questions—new points which of themselves often raised still other points which had not been broached in the Paper at all. Mr. Russell laid stress on the importance of getting not only the technical men but also the practical foundrymen in the meetings to get up and give their views and experiences. Sometimes the practical men felt that they could not express themselves well and were hesitant, but they had among them an amazing fund of valuable experience, and every encouragement should be given them to speak. Those who felt themselves tongue-tied need only say what they had in mind in straightforward simple language, and they would be listened to with the utmost respect—with as great respect as was accorded to the perhaps more versatile technical man.

Vote of Thanks.

Mr. H. Sayers (Leeds), proposing a vote of thanks to the Institute's President for his presence and encouraging address, commented particularly on Mr. Russell's final point as to the value of the experience which the practical foundrymen among the members could give in the discussions on Papers. He (Mr. Sayers) felt that if the whole of the knowledge, gained from experience, of the practical men could be pooled to general mutual benefit there would be very few foundry difficulties left to be solved.

Mr. A. S. Worcester (Huddersfield) seconded the vote of thanks, which was carried enthusiastically.

Shrinkage Holes.

MR. P. A. RUSSELL, B.Sc., of Leicester, then delivered his Paper under the title, "Shrinkage Holes in Small Grey Iron Castings," which has previously appeared in THE FOUNDRY TRADE JOURNAL.

DISCUSSION.

The CHAIRMAN (Mr. Thornton) said the meeting had heard a remarkably fine Paper on a subject on which there were no doubt many points of view. It had been tackled in a manner which he felt sure would call forth a full discussion. It was a Paper which, since publiction in THE FOUNDRY TRADE JOURNAL, had created a great deal of interest, and now the West Yorkshire members could fully realise why that was so. So far as criticism was concerned, Mr. Russell had "covered his tracks" very skilfully. (Laughter.)

Rate of Cooling and Solidity.

MR. S. W. WISE (Hon. Secretary) said Mr. Russell had given an excellent Paper. If he was not coming to a too hasty conclusion, or generalising too rashly, he would be inclined to suggest that Mr. Russell's metal had been perhaps unsuitable right throughout the work covered by the Paper. Mr. Wise, commenting on one of the analyses shown on the screen—total carbon 3.0 per cent., silicon 3.0 per cent., and manganese 0.5 per cent.—said most of them would probably like a good deal of iron with carbon as low as that. The whole range of irons used was distinctly outside of his (Mr. Wise's) usual experience, and he thought perhaps they were something in the nature of freak castings selected deliberately for the purposes of the Paper. Mr. Wise said he understood Mr. Russell to say he favoured quick cooling to overcome drawing. Personally, he thought that was an open question. If Mr. Russell's theory was correct, it would seem that the "Perlit" process was basically wrong. To remove porosity by the "Perlit" process advocated casting the metal in a hot mould and lengthening the rate of cooling, which was consistent with the practice of homogenous casting. Mr. Wise said he understood Mr. Russell to say gases from chills were probably driven into another part of the casting. Was he referring to a cast-iron chill or a steel chill?

Life of Chills.

MR. RUSSELL, replying, said in regard to comments on the character of the metal, it must be remembered that he was not in a position to dictate the quality of metal he would like to use. Customers dictated in regard to machining and the firm dictated in regard to price. The particular analysis which Mr. Wise had commented on as being unusual was, he might say, taken before he (Mr. Russell) was connected with his present firm, and was at the end of the war period, when the irons available were of a very doubtful character. In regard to the ring casting which Mr. Wise suggested was not a draw but a blow or due to cold pouring, the analysis was over 3 per cent. C. If Mr. Wise had seen the casting he would probably have admitted that a draw was of a very rough nature.

MR. WISE, interposing, said he thought there were definite little blow-holes in this fracture.

MR. RUSSELL, in reply, insisted that if there was anything on the screen suggesting that it must have been faultiness in the lantern slide. Turning to the example of a strainer runner with a very big feed, Mr. Russell said it was an exceptional case, designed to show how runners could feed. Mr. Russell said he did not suggest in the Paper that gases from chills would cause a draw. With steel chills he had not had trouble with gas holes except after they had been used twenty or thirty times, but when he had ground off the face and so obtained a fresh start they had been as good as ever.

Separation of Cupola Charges.

MR. W. H. POOLE (Keighley Laboratories, Limited) said Mr. Russell was an excellent example of a highly-trained technical man tackling problems of importance, and his results must be of great value. Mr. Poole said he was inclined to think with Mr. Wise that the bulk of the irons shown for the purposes of the Paper were different from what one would say were the best of mixtures. They were obviously intended for "speed" engineers, where they were not quite so particular as to close-quality of metal.

It was of interest to note, said Mr. Poole, that Mr. Russell used three types of mixtures in the blow. In what manner were these charges separated? What was the explanation of the lower manganese in the first charges from the cupola? Could the lecturer state if the use of such large ingates was conducive to clean running? Mr. Poole said the design and type of runner appeared to him to be similar to that used for steel-moulding practice, and it would be interesting to be informed what was the average percentage of gates and runners to casting weight. The use of nails inserted in the heavy sections had been mentioned, but such procedure required care, and certainly should not be overdone. In his (Mr.

Poole's) opinion, the type of metal as shown in the analyses was generally too soft and grey for the castings under discussion, and he wondered whether Mr. Russell had been making castings for engineers who were thinking only in terms of easy machining, with little consideration for quality of the metal. Mr. Poole did not agree that the use of steel in the mix necessarily meant lack of uniformity of metal. This depended on the melting and tapping conditions and should, with good practice, be well under control. Would Mr. Russell give an explanation of the position that, as the hotter the iron the more gases held in solution, he stated that pouring hot iron gave less trouble through gas than cold iron? In the examination of "drawn" effect, would the lecturer consider that the metal structure at the draw would be of a dentritic structure if caused through a metal defect, and if this would not be so with a gas effect—but rather a smooth hole-formation as explained in the lecture?

Strainer Gates.

Replying to remarks by Mr. Poole, Mr. Russell said he agreed that the analysis was unsuitable, but analyses in the foundry could not always be helped, and in using it in the Paper he had partly in mind the fact that so many foundries could not afford to run just exactly the right iron for every particular job. If one had one's own way and expense was of no account, one would have a different iron for every job, but he took it many members of the Institute were in the same position as himself in a works of a jobbing nature, and had to face the constant problem of how to overcome troubles even when the iron was not exactly of the most ideally suitable nature. Mr. Russell said he had never found any dead white spots when making semi-steel, but there was a great risk of finding the steel concentrated in one particular tap. In regard to hot metal containing more gas, and therefore being more liable to drawing, that was admitted; but it was also generally admitted that metal melted hot also tended to hold that gas in solution even when it was solid, and a cold-melted metal would give up its dissolved gases more readily than a hot-melted metal. In regard to loss of manganese in the first charge, he (Mr. Russell) associated that with the loss of sulphur in the burning of the bed. In regard to the weight of the gates and risers, it was certainly high, but when one considered one could often run quite a large casting with good down gates one might find a slight gain in this type of runner. He (Mr. Russell) set off the extra weight against the reduced amount of occluded slag. He had certainly had slag pass down the strainers, but it had to be very liquid. They were not foolproof, and they had to be run almost as carefully as an ordinary bush.

Chilling by Use of Red Sand.

Mr. Russell said he had fully expected to get into trouble with the critics on the matter of use of nails. He did not advocate many of them, but there were circumstances in which, if they were wisely placed, he did not think there was much objection. Mr. Russell agreed with Mr. Poole that a draw through excess silicon and excess graphite created a risk of a dentritic structure. The gas-assisted draw was nearly always smooth. He wished to thank Mr. Poole for his point in regard to the chilling effect of red sand. He (Mr. Russell) had doubted it when it was first mentioned, but he tried it—he was always prepared to give a trial to anything—and it worked, and he was obliged to Mr. Poole for his explanation of it.

Mr. R. D. Welford (Bradford) said the experiences detailed by Mr. Russell made one wonder as to what was happening in foundries which had not their castings under control, especially in heavy bosses. The lecture made one cease to wonder that such castings under water pressure had leaked. If small castings could shrink in this manner what could be expected of large castings, especially when it was impossible in one casting to have metal equally suitable for both thin and thick parts. It was undoubtedly difficult, for an ordinary man in charge of a shop, where he had no personal control of his mixtures, to graduate them to suit the different castings which he had to make. Mr. Russell had mentioned the increased use of scrap, but reduced silicon. He (Mr. Welford) felt that that was a good method which was not practised as fully as it might be. On the question of gas, if it were correct—as according to some authorities—that gases only were responsible for these blow-holes, then it must be assumed that if there were no gases the castings would be perfectly sound. But if a blow-hole developed through gas, where did the excess metal show itself? Was the rest of the metal more compressed than it would be otherwise, or did it occupy space in the runner or riser? It was not a difficult matter to run two or three mixtures so long as one took care that the junction between the two kinds was run into castings which acted as a kind of buffer. Mr. Welford said it seemed to him that perhaps the reason for these castings being drawn was lack of uniformity in the irons. Was the metal taken out of the cupola in shanks or first filling a mixing ladle. Personally, he preferred to run anything up to half-ton charges into a half-ton ladle so that one might get a uniform quality of iron. The question of running through the thin parts of a casting was a practice not so general as it might well be. It was a good and simple practical way of equalising the heat of the casting. Risers were often very badly used. For instance, the drawn place in a corner, shown on one of the slides, was perhaps more likely to have been caused by gases having forced from that corner into the mould. Red sand, said Mr. Welford, was much more permeable than ordinary sand, and obviated largely these drawn places. The whole question of draws was of great importance, and if all foundries could be operated under metallurgical control and advice there would no doubt be a great reduction in these cases of drawn holes in castings, and consequently in the scrap bill. He (Mr. Welford) would sooner have scrap in the runners than he would have scrap in castings.

Mr. Russell, replying to Mr. Welford, said he did wish to insist that the average foundry did not realise how low it was possible to run silicon and still maintain a machineable iron. In reference to Mr. Welford's question as to the running of charges, in his (Mr. Russell's) case 5 cwts. was the largest ladle in use. Mr. Welford had made reference in regard to free venting red sand. The trouble occurred not in the moulding but in the analysis. The only variable would appear to be in the analysis, and he (Mr. Russell) contended that the red sand was more of a chill than a free venting kind.

Gear Wheel Blank Troubles.

Mr. F. H. Hions (Huddersfield) said he wished to congratulate Mr. Russell on the courageous way he had tackled a very interesting problem. At some period in their experience they had probably all come up against this problem of drawholes, particularly in the smaller type of castings. He had in mind a case of small castings in which there was very great trouble. So far as they knew their cupola practice was satisfactory. They had tried to control everything as well as they could. The charges were weighed, the metal and coke were carefully checked, and they cast everything as hot as possible. Yet whilst sometimes they obtained good results, often they had drawholes. One particularly troublesome case was a casting of a small pulley on a rather heavy boss. They tried various methods, including a big runner-head and a strainer, but they were not always successful. Then he experimented with a runner with some of these pulleys in a crucible-melted iron, and never had a failure, and he was wondering whether the better result was due to the absence of gases. In a series of gear wheel castings of various sizes, but all in proportion to scale, all were apparently sound except the 30-in. ones. Apart from which he could not remember a single case of any of the wheels having porosity. The moulder who was making the job put some pipe nails in.

Mr. Russell replied that he had had very little experience of casting in crucible-melted iron, and it had not helped him much. Mr. Russell agreed that crucible practice did tend to eliminate the gases, but he would rather turn his attention to the analysis of the cupola metal. In regard to the exceptional difficulty with the 30-in. gear wheel of Mr. Hions, perhaps there was some peculiarity in the actual shape of the boss which gave trouble. He was afraid he could not give any opinion on that point without having seen the job or knowing more about it in detail.

Mr. A. S. Worcester (Huddersfield) said he agreed with the lecturer in reference to a quick cooling range and in regard to the growth of graphite. It appeared as though one merely wanted a low phosphorus and a high carbon, but that, of course, did not work out in practice. Could Mr. Russell give any information as to what effect the manganese had on the condition of the carbon according to the thickness? Did the manganese affect the state of the carbon by causing a growth from nuclei sooner and so cause large graphite flakes? Mr. Worcester said he was quite in agreement with Mr. Russell in regard to runners and risers. With regard to nails, actually an ordinary tinned pipe nail was a very good thing. Mr. Worcester asked whether, in running the three mixtures, Mr. Russell did anything to separate the charges from one another?

Mr. Russell said he would like it to be understood that he was not advocating high graphite content. He was wondering whether Mr. Worcester had slightly misunderstood the point. The excessive graphite expanded the casting, but at a time when it was useless for counteracting shrinkage. The graphite should be at a certain minimum, though he was afraid he could not give figures. The high manganese decreased the plastic range and the time in which the liquid could flow away from the hot spot of the casting; it counteracted the influence of sulphur, was a good deoxidiser, and it tended to remove the gases. In regard to the question of separation of charges, some mixtures were separated and others were not. Where it was practicable, if one could control the silicon content, gradually increasing or decreasing it from one charge to the next, it was possible to control it without separating the charges, but if one had grey iron immediately followed by semi-steel one must take steps to separate them.

White Iron Castings: Hot Spots and Phosphorus.

Mr. W. Slingsby (Keighley) said he wondered if Mr. Russell, in following up the difficulties he had had with the grey iron, had ever pursued studies on a different line in the direction of white iron where one had to have the castings gas-tight. One of the difficulties was in regard to the hot spot where one could not get the cooling at the same rate as the more exposed portions. What he (Mr. Slingsby) had observed was that one could make a casting, and in the hard state it appeared to be definitely sound everywhere. When one annealed that casting, if one annealed at about, say, 940 deg. C., one had no trouble, generally speaking, with leakage at that point; whilst if one took it up to, say, 980 deg. C., these castings were likely to draw away from the hot spot. Whether it was that the phosphide eutectic had reached a higher temperature than its melting point, and been in solution, he would not be prepared to say, but it seemed to flow away and leave that definitely as a porous place. The only explanation of which he had been able to think was that probably in the casting there was a certain amount of minor porosity. One was coming to the question of capillary attraction, and he wondered whether it was that the other portions had been set first, and the fissures were so small that capillary attraction of the minor passages drew away from the larger passages which existed at the hot spot. Mr. Slingsby said he wondered whether a little study on these lines would help in finding out why the porosity was more serious with heavier castings. It was possible perhaps that the outer portion robbed the inner portion and caused a draw.

Mr. Russell agreed that the suggestion of Mr. Slingsby was quite a possibility, and to some extent he thought it did happen. Of course, the conditions between white iron and grey iron were very different.

Mr. J. R. Bacon (Huddersfield), referring to the fact that Mr. Russell put in the centre of the mould some chills, asked did the author take

(*Continued on page* 37.)

Aluminium-Silicon Alloys: Their Properties and Some Applications.

By R. B. Deeley, B.Sc., A.R.S.M.

PART I.—PROPERTIES.

The value of the aluminium-silicon alloys for use in modern engineering and manufacture, particularly as compared with the other light alloys of aluminium, is a subject which, though touched upon by a number of writers, has not received any very detailed attention. This may not perhaps be so surprising as it seems at first sight, when one considers that it was less than forty years ago that the Hall process reduced the cost of production of aluminium sufficiently to enable the metal to enter into commercial competition with the old-established metals, iron, copper, zinc, lead and tin.

In this comparatively short space of time the use of aluminium has increased so rapidly that in 1927 the world consumption was 200,000 tons, making it the fourth in order of importance as regards world production of the non-ferrous metals.

Though the metal was first isolated in 1824 by Oersted, the quantities obtained were not sufficient for a study of the properties of alloys, nor was there much object in so doing on account of the cost of the metal. The production, by Deville in 1854, of large quantities of aluminium by means of sodium cheaply obtained by Bunsen's new process, made possible a study of the alloys of the metal, and although some attention was given to the Al-rich alloys most investigations seem to have had the object of determining the effect of small quantities of aluminium on established metals and alloys.

The electrolytic process discovered by Hall in 1886, and universally employed in the manufacture of aluminium, so reduced the price that serious attention was paid to aluminium-base alloys. The properties of alloys with copper, copper and manganese, zinc, and copper and zinc formed the subjects of reports to the Alloys-Research Committee of the Institute of Mechanical Engineers, and, of course, a great amount of work was carried out during the war, but the general view of the aluminium-silicon alloys, at any rate of those with any substantial percentage of silicon, was that they were weak, brittle and liable to gas-holes and large cavities.[1] This view, which was perfectly correct in the circumstances, held until Pacz, in 1920, invented the treatment, now called *modification*, which so materially improves the properties of the alloys that they may be said to be the strongest of all the aluminium casting alloys for use in the cast state without subsequent treatment.

Modifying Treatment.

This treatment, for which Pacz was granted British Letters Patent No. 158,827, consists of treating the aluminium-silicon alloys, containing from 5 to 20 per cent. of silicon, in the molten state, before casting with an alkaline fluoride or a mixture containing an alkaline fluoride with an alkaline chloride, or even a substance which under this treatment would yield an alkaline fluoride.

Pacz stated in his Patent that aluminium-silicon alloys when produced by melting the metals together, and without the treatment which he described, had a strength when cast of from 6½ to 8 tons per sq. in. and an elongation of ½ to 1½ per cent. The extraordinary changes brought about in the alloys when treated by his process may be realised from the fact that the alloys so treated would, he stated, have a tensile strength of 10½ to 14 tons per sq. in., with an elongation of 3½ to 11 per cent. He remarked that the fracture of the untreated alloy was very coarse, dark and crystalline, while that of the treated alloy was fine-grained, light and dense. He also mentioned that the shrinkage on cooling of the treated-alloy was less than that of any other aluminium-alloy.

Several subsequent treatment-agents have been devised and patented both in this country and abroad, and among these are the alkali metals, particularly potassium, sodium and calcium and other materials, chief among which are the alkali oxides, hydrates, peroxides and sodamide.[2] All these processes are entirely satisfactory, and when properly used will produce similar results, but the most convenient and economical process to employ at the present moment is the use of metallic sodium, which is relatively cheap, very efficient, and, if suitable precautions be taken, can be stored for long periods in safety and without fear of deterioration.

THIS paper was presented to a joint meeting of the London Sections of the Institute of British Foundrymen and the Institute of Metals, Mr. W. B. Lake, J.P., presiding. The author is metallurgist to Messrs. Lightalloys, Limited, of Willesden, London, N.W.10, who are the pioneer manufacturers of Alpax. This and related aluminium-silicon alloys have now taken their place amongst the most important of foundry alloys on account of their lightness, strength in the "as-cast" condition, and good casting properties.

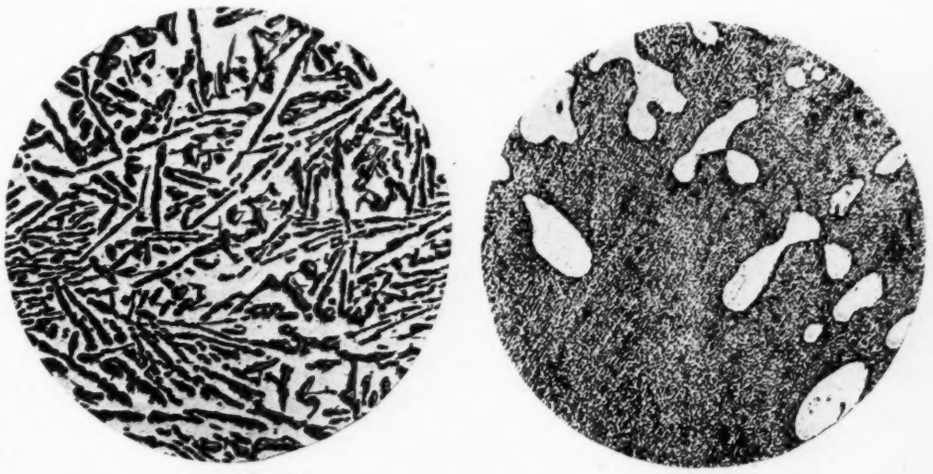
Fig. 1 shows the microstructure of the 12 per cent. silicon alloy made by melting the constituents together, and also of the same alloy when modified. In both these micro-sections only two constituents are visible, the white ground mass being practically pure aluminium, while the silicon is present as the black constituent. It will be seen that in the unmodified alloy the general structure is very coarse, and that the silicon is present either in the form of long needle-shaped crystals, or as large polygonal crystals. In the modified alloy, however, the silicon occurs as very small curly particles. It will be seen from Fig. 2 that the effect of modification on the appearance of the fracture is very similar to the effect on the internal structure of the alloy.

Theories of Modification.

There have been many theories advanced to explain the mechanism of this phenomenon called modification, and one of the earliest was that modification was due to the removal of aluminium oxide by the fluxing action of the modifying agent. This theory, however, would not seem to be sound, for several materials which are known to dissolve aluminium oxide (in particular sodium bisulphate) do not act as modifiers. It has been suggested also that the aluminium-silicon alloys can exist in two states, the one stable and the other metastable, but since the aluminium-silicon alloy system shows a complete absence of metastable constituents, and as no allotropes of aluminium have so far been discovered, this theory does not appear to be tenable. That modification is due to a ternary alloy being formed with sodium has been suggested, but this also is considered unlikely as certain sodium compounds which are known to be reduced by molten aluminium do not produce modification.

That modification consists essentially of a peculiar type of refinement of crystal size, particularly of the silicon crystals, is completely proved by the results of Jeffries'[3] investigations with the X-ray spectrometer, when he found that the diffraction pattern obtained either with the modified or with the unmodified alloy was the same and was that corresponding to a mixture of silicon and aluminium crystals.

There are three other theories which have been advanced to explain the phenomenon of modification, and, since two of these are based on the colloid theory, it may be advisable to recall some of the properties of a colloid. Now, when one substance is dissolved in another to form a truly homogeneous solution it is generally understood that the largest particle of either substance present in the liquid is a molecule—that is to say, the liquid solution consists of an intimate mixture of molecules of the two substances. Crystals are large numbers of molecules arranged in a definite formation, and, if a true solution as defined above be subjected to some influence which reduces the solubility of the dissolved substance in the solvent, groups of molecules will associate together and form crystals of a size visible to the naked eye or at least to a microscope. It is known also that certain solutions can exist in a state known as colloidal when the dissolved substance may be present in the form of groups of molecules which are not visible even to the ordinary microscope. Such a colloidal solution is very sensitive to additions of certain other substances which in colloid chemistry are known as protectors and coagulants—protectors tending to protect or stabilise the colloid state by preventing further molecules joining the groups already formed and thus preventing growth to and deposition as crystals; coagu-

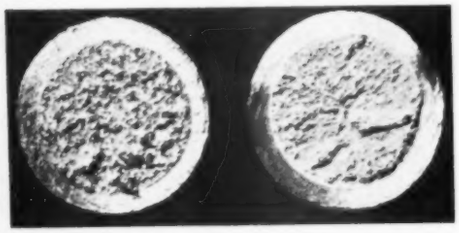


UNMODIFIED. MODIFIED.

FIG. 1.—MICROSTRUCTURE OF SAND-CAST 12 PER CENT. SILICON ALLOY, MODIFIED AND UNMODIFIED, × 100. CONSTITUENTS:—SILICON, BLACK; ALUMINIUM, WHITE. UNMODIFIED ALLOY ALMOST OF EUTECTIC COMPOSITION; MODIFIED CONTAINS EXCESS ALUMINIUM.

lants accelerating the growth of the colloid particles.

The first of the three theories is that advanced by the Staff of the Research Bureau of the Aluminium Company of America,[4] who consider that when the modifier is added to an aluminium-silicon melt it disperses in particles of colloid dimensions, and, as the melt cools, impedes the normal growth of the silicon particles. In the second theory, which is from the same source, it is suggested that the alkali metal used as a modifier is absorbed as a film at the surface of the particles of silicon as they form in the liquid, thereby impeding their growth.



UNMODIFIED. MODIFIED.

FIG. 2.—FRACTURE STRUCTURES OF 1-INCH DIAMETER SAND-CAST BARS OF MODIFIED AND UNMODIFIED 12 PER CENT. SILICON ALLOY. NOTE COARSENESS OF UNMODIFIED AND CLOSENESS OF MODIFIED. (COMPARE FIG. 1 OF THE MICROSTRUCTURE.) FULL SIZE.

The third theory, and the one which most closely fits the facts is that developed by Dr. Gwyer and his colleagues of the Research Laboratories of the British Aluminium Company.[5] In this theory it is suggested that the aluminium silicon alloys on cooling from a temperature well above their melting point, and, therefore, in a state of true solution, pass through the colloidal state, and are susceptible to the influence of substances which may act either as protectors or coagulants. The various known modifiers act, they suggest, as colloid protectors, causing more or less complete stabilisation of the colloid state whereby that state tends to persist after solidification. As regards coagulants, they have found that sodium chloride brings about complete reversion of the modified alloy to the normal state. It follows from this theory that the best results would only be obtained if the correct quantity of modifier or protector were used. This is, in fact what happens in practice, for it is found that on adding progressively increasing quantities of modifier to the normal alloy, the properties are improved up to a certain percentage addition, after which there is a gradual deterioration.

The persistence of the colloid state after solidification, or, in other words, modification, may be brought about without the use of a chemical modifier by means of ultra-rapid chilling, such as quenching from the molten state into iced brine. Such an exceedingly rapid rate of cooling is not possible in ordinary practice, especially in the case of sand castings, and it is therefore necessary to modify the alloy chemically. The chilling effect of an ordinary chill mould is insufficient to bring about complete modification, as will be seen from Fig. 3, in which it may be noted that the silicon particles, though small, have the characteristic needle-shaped formation of the normal or unmodified alloy.

In further testing their theory, Gwyer and Phillips[5] have found that it is possible to modify and coagulate other alloys, particularly those of aluminium and copper, aluminium and manganese, aluminium and iron, aluminium and nickel, and antimony and copper.

Constitution of the Alloys.

The normal alloys were first studied by Fraenkel[6] in 1908, and later by Roberts[7] in 1914, and by Rosenhain, Archbutt, and Hanson in the 11th Report of the Alloys Research Committee of the Institution of Mechanical Engineers.[3] The modified system has been studied by Gwyer and Phillips[5] in this country and by the Research Bureau of the Aluminium Company of America in the United States.[4]

Both when modified and unmodified, the alloys form a simple eutectiferous series with very slight solubility of silicon in colid aluminium. In the normal series the all eutectic-alloy contains 11.7 per cent. silicon and freezes at 577 deg. C. In the modified alloys, however, it is found that modification, besides refining the structure, also depresses the freezing point and increases the silicon-content of the all-eutectic alloy. The freezing point of the modified alloys may be as low as 561 deg. C., but the composition of the all-eutectic modified-alloy is greatly influenced by the rate of cooling, and Gwyer and Phillips have found the all-eutectic structure present in a rapidly-chilled modified alloy containing as much as 15 per cent. silicon. It will be appreciated, therefore, that any equilibrium diagram given for the modified alloys will only hold for a particular rate of cooling. Fig. 4 gives both the modified and unmodified alloys plotted on the same diagram. It is taken from Gwyer and Phillips' paper, and it will be seen that for the particular rate of cooling employed—8 to 10 deg. C. per minute—the composition of the all-eutectic alloy is 12.85 per cent. silicon. Fig. 5 is taken from a paper[4] by Archer and Kempf of the Aluminium Company of America, published in March, 1926, to the American Institute of Mining and Metallurgical Engineers. The rate of cooling is more rapid, and approximates to that of alloy cast in a sand-mould. It will be seen that in this case the composition of the all-eutectic modified alloy is approximately 14 per cent. silicon.

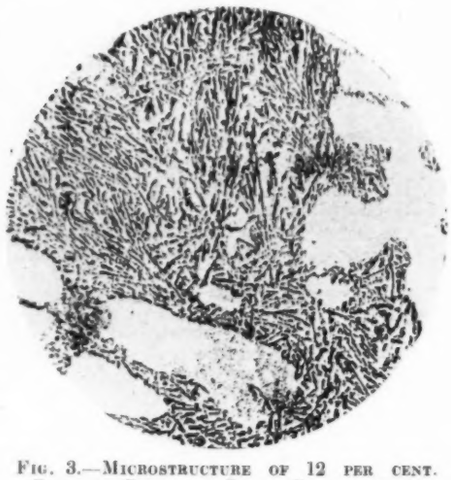


FIG. 3.—MICROSTRUCTURE OF 12 PER CENT. SILICON CAST IN IRON CHILL WITHOUT MODIFICATION, SHOWING INCOMPLETE REFINEMENT OF SILICON PARTICLES WHICH, THOUGH SMALL, ARE NEEDLE-SHAPED. (× 100.)

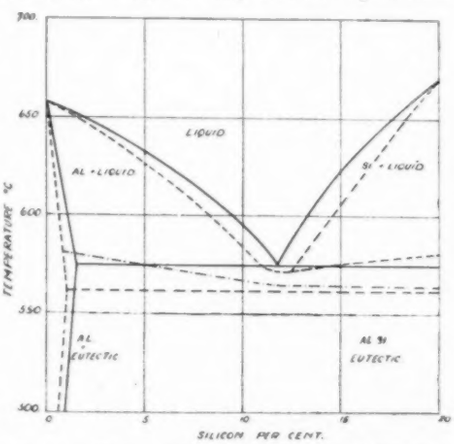


FIG. 4.—EQUILIBRIUM DIAGRAM FOR MODIFIED AND UNMODIFIED ALLOYS — GWYER AND PHILLIPS. (RATE OF COOLING 8-10 DEG. C. PER MINUTE. UNMODIFIED—FULL LINES: MODIFIED—DOTTED LINES.)

From the point of view of microstructure, the alloys are, therefore, divisible into three groups, as follows:—

(1) Those with less than 11.7 per cent. silicon, which, both in the normal and in the modified state, consist of dendrites of primary aluminium in eutectic ground mass; (2) those alloys whose compositions lie between those of the normal and modified all-eutectic alloys. These contain from 11.7 to approximately 14 per cent. silicon, and when unmodified consist of primary-silicon crystals in a ground-mass of normal eutectic. When modified, however, they consist of dendrites of primary-aluminium in a ground mass of modified eutectic; and (3) in this group are the alloys containing more silicon than the all-eutectic modified alloy, and whether modified or normal they consist of primary-silicon crystals in a eutectic ground-mass.

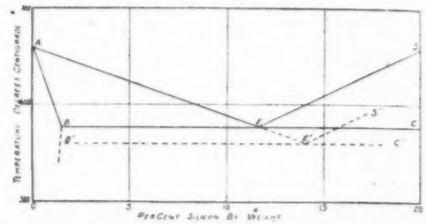


FIG. 5.— EQUILIBRIUM DIAGRAM FOR MODIFIED AND UNMODIFIED ALLOYS—ARCHER AND KEMPF. (RATE OF COOLING EQUAL TO SAND CASTING.)
(UNMODIFIED — FULL LINES: MODIFIED—DOTTED LINES.)

Practical Consideration of the Modification Process.

The process of modification which consists essentially of adding the modifier to the metal, and allowing the metal to stand for a certain period of time, without any stirring, before casting is carried out, contains a number of variables which are not met with in the casting of other metals and alloys. The actual temperature at which casting is to be carried out is fixed as in the case of any metal or alloy by the size and general shape of the casting, particularly by the thickness and the extent of the thinnest section of the casting.

The temperature at which casting must be carried out, automatically fixes the temperature at which modification must be applied to the melt, and also the time period. Among the most influen-

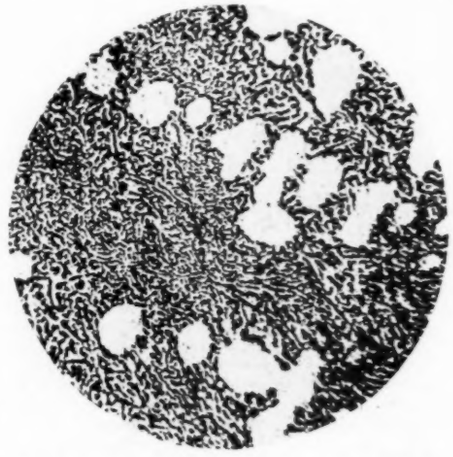


FIG. 6.—MICROSTRUCTURE OF SAND-CAST 12 PER CENT. SILICON ALLOY, CAST TOO SOON AFTER MODIFICATION, SHOWING INCOMPLETE REFINEMENT OF SILICON PARTICLES. (× 100.)

tial variables which are peculiar to the casting of modified aluminium-silicon alloys, are:—

(1) The quantity of silicon in the alloy to be modified; (2) the quantity of modifier used; (3) the time allowed to elapse between modification and casting; and (4) the thickness of section of the casting cast.

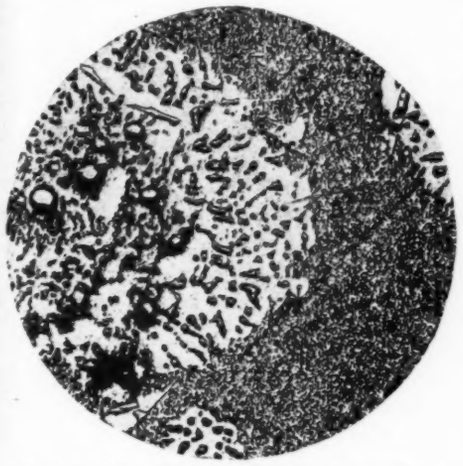


FIG. 7.—MICROSECTION OF SAND-CAST 12 PER CENT. SILICON ALLOYS, CAST TOO LONG AFTER MODIFICATION, SHOWING AREA OF REVERSION TO UNMODIFIED STATE. (× 100.).

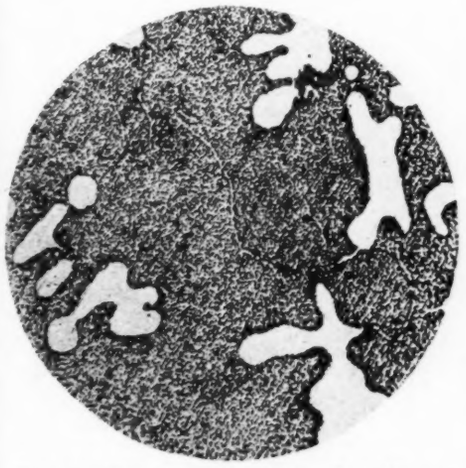


FIG. 8.—MICROSECTION OF SAND-CAST 12 PER CENT. SILICON ALLOY, MODIFIED WITH TOO MUCH MODIFIER; SHOWING COLONISATION OF EUTECTIC. (× 100 D.)

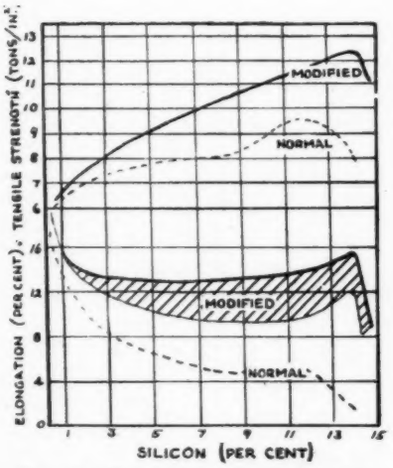


FIG. 9.—EFFECT OF SILICON CONTENT ON TENSILE STRENGTH AND ELONGATION OF MODIFIED AND UNMODIFIED ALUMINIUM - SILICON ALLOYS (ARCHER AND KEMPF.)

Considering firstly the quantity of silicon present in the alloy to be modified, though the commercially-useful alloys contain anything from 3 to 20 per cent. silicon, those having the best combination of properties, contain from 10 to 14 per cent. Archer and Kempf[4] have shown that the amount of modifier required varies with the silicon content of the alloy, increasing as the silicon increases.

It is impossible to give any details as to exact quantities, for the class of work being done, the particular modifier used and a number of other factors cause great variations in the amount of modifier required.

With regard to the quantity of modifier used with any particular silicon content, it appears quite general that the amount of modifier and the time period are closely inter-dependent, and that if the amount of modifier be increased the time period must also be increased and *vice-versa*. From this it would seem that in order to obtain the optimum properties in an aluminium-silicon alloy, the alloy must be cast at just that particular moment after modification has been carried out, when the sodium or other modifier left in the alloy has reached a definite percentage. This is largely a speculation on the author's part, but it seems to be borne out in actual practice.

In order to reduce the variables as much as possible, it is perhaps best to work with an alloy of uniform composition, to use always a standard proportion of modifier to melt treated, and to vary only the time period and modification and casting temperatures as may be required by the greatest and smallest thicknesses or sections, and the general size of the job in hand.

Assuming, therefore, that a standard quantity of modifier be used, and the time period be varied, it will be found in practice that if the pouring be carried out too soon after the modifier has been applied to the melt, the casting will contain many gas holes, and the maximum properties will not be obtained. Fig. 6 shows the microstructure of a casting made in alloy containing 12 per cent. silicon, which was cast before the necessary time between modification and casting had elapsed. It will be noted that full refinement of the silicon particles of the eutectic has not been obtained.

After the correct time period has elapsed, the alloy tends to revert fro mthe modified to the normal state, and a casting cast from alloy which has been standing too long after modification has been carried out will show patches which have reverted to the normal state, the amount and size of these patches depending on the time which has elapsed since the correct casting time. The ultimate result of allowing alloy to stand for a long time after modification is, of course, that the alloy reverts to the fully normal condition. Fig. 7 shows the microstructure of a sand casting which was cast too long after modification had been carried out. It will be seen that in the particular field shown there is a large area of aluminium containing large crystals of massive

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[3] Jeffries: Chem. & Met. Eng., 1922, Vol. 26, p. 760.

[4] Archer & Kempf: Trans. Am. Inst. Min. and Met. Eng., 1926, Vol. 73, p. 581.

[5] Gwyer & Phillips: "Constitution and Structure of Commercial Aluminium, Silicon Alloys." With appendix on the properties by Stockdale and Wilkinson. J. Inst. Met., 1926, Vol. 36, p. 283.

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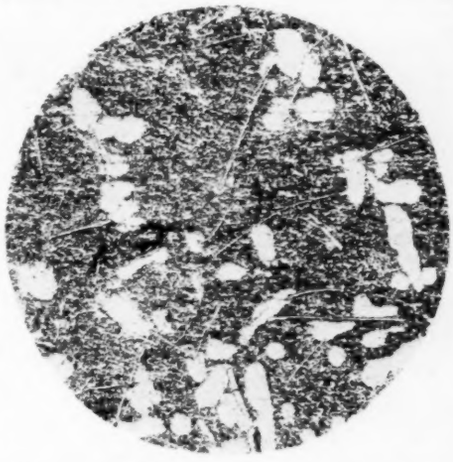

FIG. 10.—MICROSTRUCTURE OF SAND-CAST 12 PER CENT. SILICON ALLOY CONTAINING 0.72 PER CENT. IRON. IRON CONSTITUENT SHOWS AS LONG WHITE LINES. (× 100.)

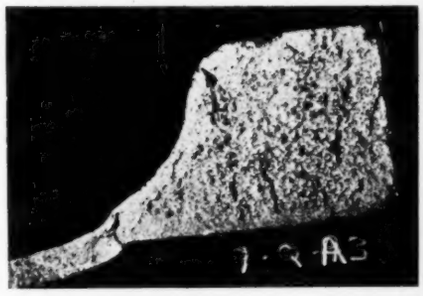

FIG. 11.—FRACTURE STRUCTURES OF SAND-CAST 12 PER CENT. SILICON ALLOY CONTAINING 0.72 PER CENT. IRON. NOTE THE FLAT, BRIGHT PLATES OF IRON-RICH CONSTITUENT IN THE ALLOY, CONTAINING 0.72 PER CENT IRON.

FIG. 12.—MICROSTRUCTURE OF SAND-CAST 12 PER CENT. SILICON ALLOY CONTAINING 2.28 PER CENT. IRON, SHOWING SECTION OF LARGE PLATES OF IRON-RICH CONSTITUENT. (× 100.)

silicon. The use of too much modifier causes colonisation of the eutectic and local reversion as may be seen from Fig. 8. The effect on the mechanical properties is to reduce considerably the elongation.

The Choice of Alloy.

Fig. 9 shows graphically the tensile strength and elongation of the normal and the modified alloys, as determined by Archer and Kempf* on test-bars cast to size in sand moulds. It will be seen from this that, with the particular rate of cooling used, the strongest alloy in the modified system and the one with highest elongation is that containing 14 per cent. silicon, and, at first sight, it would appear that, in order to obtain optimum properties, this alloy would be the best to select. It must be remembered, however, that the figures from which these curves were constructed were obtained on test-bars cast under carefully controlled conditions. All the variables occurring in carrying out such tests as these were varied until the best conditions were found for each alloy tested, and the values indicated represent, therefore, results which can only be obtained with such very careful control as was used by Messrs. Archer and Kempf, and cannot always be anticipated in practice. Even the most scientifically-controlled modern foundry cannot expect in production to copy the results obtained in the laboratory, and, therefore, must be allowed some latitude or "safety factor" in applying the processes devised in the laboratory.

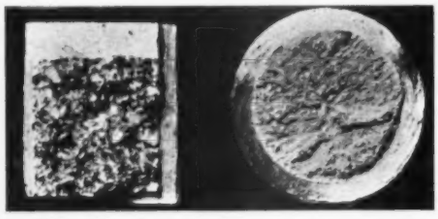

FIG. 13.—FRACTURE STRUCTURES OF SAND-CAST 12 PER CENT. SILICON ALLOY, CONTAINING (LEFT) 2.28 PER CENT. IRON, (RIGHT) 0.30 PER CENT. IRON, SHOWING FLAT BRIGHT PLATES OF IRON-RICH CONSTITUENT IN THE ALLOY CONTAINING 2.28 PER CENT. IRON.

The 14 per cent. silicon alloy is a "borderline" alloy. It contains such an amount of silicon that under the best possible operating conditions a sand casting made from it will have the all-eutectic structure. There is a grave risk, however, when using this alloy that, if the operating conditions are not precisely correct, primary-silicon crystals will separate from the melt and will cause a very serious drop in the elongation.

It is customary, therefore, to use an alloy containing not more than 13 per cent. of silicon.

Effect of Impurities.

The most common impurity found in these alloys is, of course, iron, and its effect on the properties of the alloy is not so apparent in chill castings as in sand castings. In sand castings it is safe to allow the iron to rise to a value between 0.6 and 0.7 per cent., but the exact figure cannot be given, as it depends on the rate of cooling. If the iron content rises above the latter value, a new constituent, consisting of silicon, aluminium, and iron, will separate out as large flat plates, and these cause planes of weakness and discontinuity in the alloy, greatly reducing the tensile strength and elongation. Fig. 10 shows the microstructure of a sand-cast alloy containing 12 per cent. silicon and 0.72 per cent. iron. Fig. 11 shows the fracture structure of the same alloy.

This example has been chosen because it shows what may happen in an ordinary foundry if the iron content is allowed to increase slightly. The effect of allowing the iron content to rise to higher values is, of course, to increase the amount and size of these iron-rich plates. Figs. 12 and 13 show respectively the micro- and fracture-structures of an alloy containing 2.28 per cent. iron and 12 per cent. silicon. Such an alloy is extremely brittle.

(To be continued.)

"Home-Made" Moulding Machinery.

Is it ever profitable for a firm to make its own plant? The subject is an interesting one. There are many specialist firms who make first-class foundry tackle, and who have a difficulty in keeping their works employed at the present time, yet the writer has visited several foundries recently who were constructing moulding machines, building furnaces and erecting core ovens of their own make. Many firms—or is it foundry managers—appear to think that they can make equipment cheaper and more suitable for their work than they could obtain it from firms specialising in foundry-plant manufacture.

This is an age of specialisation in engineering, and one has only to examine with care the catalogues of a foundry-plant maker to realise how foolish it is for a firm to make a "home-made" machine. The specialist firm has the advantage that it profits by every machine installed in a customer's works. After-sales service brings information of how the construction and the performance of a machine can be improved by re-designing details. Thus, when a foundry buys a moulding machine it does not merely obtain a machine at a cheaper price than if it were made in the firm's own works, but a machine that has been well tried out in practice.

In course of time foundrymen will recognise that the manufacture of any kind of foundry plant is a specialist's job. Even in laying out a foundry it is wise to consult a foundry engineer. We have seen ferrous and non-ferrous foundries developed in the last few years without a definite effort being made to reduce handling of raw material or the finished product. We are not referring now to the location of the foundries in engineering works, but to the location of sand bins, the storage of metal, the position of the core shop, etc. In the smallest jobbing foundries, with practically no plant, it is impossible to make a mistake, but when there are moulding machines for repetition work, or heavy castings are made, it is very different.

There is, no doubt, a prejudice in certain quarters against the foundry engineer, but his advice, if not indispensible, is extremely valuable in laying out a new foundry or developing an old one. The foundryman's job is the production of castings, and he cannot claim to have knowledge of lighting, ventilation, or the best layout for cheap and satisfactory production.

Apart from "home-made" equipment, one sometimes sees machines in foundries that are quite unsuitable for the work done. We were in a foundry recently where a large jolting-machine, that had been bought secondhand, was being installed. The class of work done by the foundry was mostly light and small. In this case we do not think the foundry was to blame, but the management of the engineering works, who probably thought they had secured a bargain.

With regard to melting equipment, one can understand what may be termed cupola prejudices; solid and drop-bottom cupolas have each their advocates, and the class of work the foundry undertakes, and the conditions have to be considered. For general work in an iron foundry there is no alternative to the cupola, and the main differences between one cupola and another are in connection with hoists and charging platform, although the far-seeing foundryman will consider the claims of all cupolas before deciding which is most satisfactory for his purpose. In the brass foundry there is a wide choice, although coke-fired furnaces of orthodox type are often installed without oil, gas, or electric furnaces being considered.

The limited experience of one man may cause a decision in regard to plant installation that will cause his firm heavy losses. Very often the initial cost is the deciding factor, and efficiency is considered afterwards. It is surely a wise practice when installing new equipment to consider upkeep charges, and also what machines or furnaces are going to lower production costs. It is a fact beyond dispute that plant of any kind made by a non-specialist firm is generally a bad investment, and the same can be said of good plant that is unsuitable for the work for which it is used.

Big Contracts Secured.

Good News for Notts and Derbyshire.

A much better feeling as to the future prevails among those engaged in the Notts and Derbyshire foundry industry, and recently the various firms have received useful contracts. So far as the Staveley Coal and Iron Company, Limited, is concerned, our representative has learned some very encouraging news with regard to the contracts, which, no doubt, will be received with delight by the employees. At the Stanton Ironworks, too, the men are working good time. This firm has secured a contract which amounts to several thousands of pounds.

Amongst the contracts recently received by the Staveley Company for cast-iron pipes is one for 7,500 tons 27-in., 30-in. and 33-in. for the Bristol Waterworks; another for 3,575 tons 3-in. to 14-in. for Messrs. William Wilson; one for 1,000 tons 4-in., 6-in. and 12-in. (concrete lined), for the Birmingham Corporation; and another for 1,250 tons 4-in. to 12-in. for the Glasgow Corporation.

The Staveley Company have also been paying attention to improvements, and a new plant has recently been installed for the lining of cast-iron pipes with concrete, and this has now commenced operation.

Our representative learns that, so far as the Stanton Ironworks are concerned, the Hastings Town Council have accepted the tender of this company for cast-iron pipes for water mains at a price of £13,315, although the quotation was about £1,000 more than a French tender. There was no difference in the quality of the pipes, but the Committee of the Hastings Corporation took the view that, as there were so many men unemployed in this country, it was essential to make a little sacrifice in taking home-produced goods.

The Nickel Merger.

A circular has been issued to shareholders of the Mond Nickel Company, Limited, giving full details of the proposed amalgamation of the company with the International Nickel Company of Canada, Limited, and urging them to effect an exchange of shares. The essential particulars of the scheme were published in our last issue. The circular is accompanied by a personal letter from Lord Melchett in which is enclosed a letter to Lord Melchett from Lord Weir, who recently carried out an inspection in Canada and the United States of the properties of the International Nickel Company of Canada.

It is pointed out in the circular that the principal properties of the Mond Nickel Company are in Canada, in close proximity to those of the Canadian Company. The supplies of raw material for the refinery and rolling mills in Great Britain are entirely derived from the Canadian properties. The Frood Mine, it is stated, contains a large and rich deposit of nickel-copper ore, part of which is at present owned by the company and by far the major part by the Canadian Company, and the bulk of the future supplies of ore for nickel production will be derived from this mine. If a fusion of interests does not take place, it will be necessary for the company to incur heavy capital expenditure in sinking an additional shaft and in building a large crushing plant and smelter. Further, the treatment costs of the ore and matte would be considerably higher if the tonnage were treated in two plants rather than in one. The products of the two companies are practically identical, and it is considered that if they unite to develop their common interests, important economies in capital expenditure, and in cost of manufacture, distribution, research, propaganda and management will result.

Death of Derby Foundryman.

The death has occurred of Mr. William Walker, a well known Derby foundryman employed by Messrs. Haslam's foundry for over 30 years. He was highly respected, and at one time took a very active part in various movements.

"Copper-Alloy Steel Sheets."—The Inland Steel Company, Chicago, U.S.A., has issued a booklet entitled "Inland Copper-Alloy Steel Sheets," which gives an interesting description of the product, including the details of its production and considerable data on the corrosion test conducted by the American Society for Testing Materials.

Production of Malleable Castings.*

By F. H. Hurren.

The production of malleable castings may be divided into two distinct stages—the actual production of the casting on the foundry floor and the subsequent heat treatment. In the actual production of the casting there are two important points to be taken into consideration. Firstly, the composition and class of iron charged into the cupola; and, secondly, the feeding and gating of the casting. The latter is governed by the former. For general engineering work the ultimate result to be aimed at is a tough, ductile, free-machining casting, giving a minimum tensile strength of 20 tons per sq. in., with an elongation of not less than 5 per cent. on 2 in. The casting must be free from draws, hard spots, contraction, cracks, and, of course, all the other defects to which ordinary grey-iron castings are prone.

The pig-iron as charged to the cupola has a white or mottled fracture, and should contain between 2.9 and 3.3 per cent. total carbon, mainly in the combined form. Silicon should be between 0.6 and 0.8 per cent. Sulphur should be reasonably low; that is, less than 0.2 per cent. Manganese should be at least twice the sulphur content, and phosphorus must not exceed 0.2 per cent., but should be less than 0.15 per cent.

Some founders consider it policy to use one brand of iron only and endeavour to obtain supplies falling within the above limits; others to use two or more brands of irons of white and grey fracture, and mix varying proportions of each to obtain the desired result. Opinion is very much divided on this subject, but it is considered that the use of one brand only is preferable. Experience has shown where two different brands of iron will not give a homogeneous mixture on melting, and castings from one day's pouring differ widely not only in fracture but also in chemical composition.

A cupola charge is made up from pig-iron, scrap and runners from previous casts, and may have with advantage small additions of steel scrap and annealed scrap. The annealed scrap should not exceed 5 per cent. of the total charge, and it is advisable, except in rare instances where the total carbon in the pig-iron is very high, to keep the steel scrap at not more than 10 per cent. of the total charge. The proportions of pig-iron and scrap from previous casts must be so balanced that the average silicon content of the mixture as charged in the cupola approximates to 0.75 per cent. With normal melting practice this should give a silicon content of approximate 0.55 per cent. in the hard casting.

The weight of each charge should be slightly less for malleable iron than would be used for grey iron, and the intermediate coke charges slightly higher in proportion to the iron charge than would be the case for grey iron. Personal experience is that malleable iron requires 3¼ cwt. of coke per ton of iron melted, excluding the bed coke. Owing to the low silicon content the molten iron must have a greater degree of superheat than grey iron to run sharp and sound castings. There is a very sudden change in cooling, and metal which is not of the correct degree of heat when tapped out will "go off" quite suddenly in the shank and change quickly from the liquid to the pasty state. The blast-pressure is to all practical purposes the same as in grey-iron melting, but may be somewhat higher without detriment. A pressure of 12 oz. should be quite sufficient. Excessive blast-pressure will cause undue loss of silicon and the risk of dull iron. In all other respects the operation of the cupola is exactly the same as in grey-iron practice.

Making Moulds for Malleable.

One of the first things to take into account is that a low silicon iron has a very great liquid shrinkage and a high percentage contraction. The usual contraction allowance on patterns for malleable iron is 1 to 60, but the actual contraction in the hard casting is more than this, and an expansion takes place during the annealing process. Contractions differ according to the shape and general design of the casting, but in the hard casting may be as much as 3 per cent. It will be understood that the problem of contraction is a very real one with malleable castings, and may give rise to a costly scrap account. Heavy sections, unless properly fed, will be spongy and cause a scrap casting. Thin sections adjoining heavier sections, owing to the difference in the rate of cooling, will be subject to contraction cracks, and liable to give what is known as a "sear." This may not be easily visible in the hard state, but will show up more prominently after annealing and cause rejection. Sometimes with an intricate casting the cooling stresses will be so great that the casting, if left in the sand until cold, would actually break asunder in some part of the casting. With castings of awkward design it is always advisable to remove them from the mould as soon as possible after pouring, and place in a muffle furnace previously heated to 850 deg. to 900 deg. C. This muffle is allowed to cool down slowly over a period of hours during the night and castings withdrawn the next day. The slow cooling entailed during this operation relieves the casting strains, and is of infinite assistance in the production of sound castings. This process is only effective if the castings are removed from the sand as soon as they have set and whilst still red hot.

Gating and Feeding.

It often happens that the feeding of heavy sections in a malleable casting necessitates additional partings in the mould, and a casting that in grey iron could be made with safety as a two-part job, may require a three-part or even four-part mould in malleable iron. The prevention of sinking or "drawing" in castings is not always practicable with chills, although the use of chills is more general than was the case even ten years ago. The common practice is to feed a heavy section by ramming up in the mould adjacent to the section a conical block known as a "knob" or "pound," and joined to the casting by a feeding gate. It is important that there should be a definite relationship between the size of the knob, the area of the feeding gate and the area of the section of casting to be fed. If the knob is too small it will solidify before the casting and in consequence will not perform any useful function. If too large there is extra metal to be melted and returned to the cupola as scrap. The area of the feeding gate must be rather more than the area of section to be fed. It will be realised that if the area of the gate is small, the gate will solidify before the casting and prevent the knob from serving its purpose. On the other hand if the area of the gate is on the heavy side, there is a danger of the casting feeding back into the knob with the result that the knob will be sound at the expense of the casting. If it is possible, it is best to ram up the knob in such a position that the large end is in contact with the pattern, and then join up by enlarging the area of contact. Another point to bear in mind is that, like grey iron, the feeder must be above the level of the section of casting to be fed, and not below.

There is no hard and fast rule as to what size the feeders should be for different sections of castings, as one can only be guided by experience and determine by trial and error the position and size of feeding knobs. It is always good policy when a pattern for a malleable casting is first put into the shop, to make one or two castings with different runners and feeders and break the hard castings piece by piece. Any unsoundness is easily detected by the fracture. The metal should show a white crystalline fracture, but any areas showing a discolouration, which may vary from very light brown to black, will be unsound after annealing, and the darker the discoloration the greater will be the unsoundness.

Runners for malleable castings as a rule are not cut direct from the pouring gate to the casting. Wherever possible it is good practice to interpose what is known a a "spinner." This is of a similar shape to the feeding knob mentioned before and with the entrance and exit for the metal cut tangentially. The object of the spinner is that as the metal passes down the pouring gate and enters the spinner, it is given a rotary motion. Any dirt, slag or kish goes to the centre and rises up towards the top of the spinner. Clean metal is drawn from the sides of the spinner, and passes along the remainder of the runner and into the mould. Now, here is where a little lack of thought in cutting the runners and placing the spinner will not only nullify the effect of the spinner, but will make matters worse than if a spinner was not used. The point to bear in mind is that the outlet from the spinner must be tangential to the circumference, and in the opposite direction to the flow of metal.

In other respects the gating follows grey-iron practice, and the actual junction of the gate and casting may be a single entrance or a spray gate. Personal opinion is that a series of small flat gates in the form of a spray has many advantages over the large single gate. Grinding off the rough edges of the gates after annealing is easier with the spray gate, and less likely to give a very aggravating source of trouble, namely a hard patch. This is more likely to occur if heavy pressure is put on the grinding wheel by the fettler, when considerable heat may be generated. If the runner happens to be on a machined part of the casting, it may be found that the tool "jumps" every time it passes over that part, due to hardness set up by the fettling operation.

After the hard castings have been removed from the sand or from the muffle furnace, the cores are knocked out, and the castings either wire-brushed, cleaned in a tumbling barrel, or sand-blown. The latter process has decided advantages over hand-brushing, although it may be more costly, as the castings come from the sandblast so much cleaner than is possible by brushing. Those castings which have been muffled are very difficult to clean by hand, as the sand is burnt on to the surface and can only be removed after great labour.

The tumbling barrel consists of a cast-iron or wrought-iron cylinder revolving horizontally on its axis. The barrel is packed with hard castings and a number of "stars" or rough-edged pieces of hard iron intermixed with the castings, the barrel being not more than half or two thirds full. The filling door is placed on and either cottared or screwed down. The machinery is set in motion and the barrel revolves at the rate of 10 to 15 r.p.m. For very small work the speed may be increased. The castings rub against one another, and after about 20 mins. the machinery is stopped and the castings removed. There is always a danger that some of the castings may be broken during this operation, and heavy castings should not be packed with fragile castings.

In spite of the fact that the sandblast is much more expensive to instal than the tumbling barrel, experience has shown it exceedingly useful for cleaning both hard and annealed castings. Any defects are more easily visible and a more rigid inspection before annealing is possible. The sand-blown castings are in a better condition for the annealing process than those which have sand burnt on to the surface. All hard castings must be subject to close examination for the usual ailments, scrap rejected, and doubtful castings put on one side for further examination by the foreman in charge. The castings then pass on to the second stage in production, that is the annealing.

Annealing Process.

Broadly summarised, annealing consists of a lengthy period of heating, at a high temperature out of contact with the atmosphere, or in contact with a suitable reducing medium, followed by slow cooling. During this process part of the total carbon is eliminated, and part is changed from the combined to the free or graphitic state. The main difference in chemical analysis between a casting as cast and after annealing lies in the quantity and form of the carbon content. The

* A Paper read before the Newcastle Branch of the Institute of British Foundrymen, Mr. C. Gresty presiding.

sulphur content usually increases during annealing and the other constituents remain practically unaltered.

There are several types of furnaces for annealing, the simplest being a rectangular chamber lined with firebrick, with a flue outlet in the centre of the arch, and a pit running down each side of the furnace for coal firing. In more modern types the actual combustion of coal takes place outside the furnace and the gas as generated is led into the main body of the furnace by a system of underground flues. Annealing furnaces are also fired by producer gas, but this is used only in large works which have a number of large ovens.

As the hard castings come from the foundry they are sorted into various sizes of casting and thickness of section. A small thin casting will not require so much annealing as a large casting or one of heavy section, and the treatment that would suit the thin casting would leave the thick casting hard and insufficiently annealed. On the other hand if a thin casting were subjected to the same heat treatment as would be suitable for a thick casting, it would be over annealed, an outer skin might peel off, and the casting would give low physical tests. An annealing oven never attains an equal degree of heat for an equal time in all parts. Some parts of the oven are the last to attain annealing temperature, during firing, and may be the first to start cooling off when firing ceases.

As a compromise, castings are so placed in the ovens that the heavy castings go in what is known as the hottest parts of the furnace, and the thinner castings in the cold parts. These areas can only be discovered by experience and test for different furnaces. The castings are first placed in white-iron pots, called annealing-cans. These may be cylindrical, square or rectangular in shape, according to the style of work to be annealed and the whim of the annealer. In the author's works he uses cylindrical cans of four standard diameters, and two standard depths. The diameters are 12, 14, 16, and 19 in., and the depths 13 and 10 in. For special work it may be necessary to use larger cans, but the above provides a good range for castings for general engineering. The cans can be built up one on top of the other, and with a long casting it may be necessary to use a bottomless can, or annealing rim, to obtain the necessary height. These stacks may consist of four or five cans and the object of having two standard depths is to vary the height of the stack according to the nature of the castings and the position in the oven. The top of the stack should always be at least 10 ins. from the arch of the furnace.

As the castings are placed in the annealing cans they are covered with an oxide of iron, known as annealing ore. As purchased, this consists mainly of ferric oxide, Fe_2O_3, is bright red in colour, and usually graded to size. That most generally used is about pea size. After passing through the annealing furnace, this red ore becomes black or dark blue, and consists of both ferric and ferrous oxides. The ore is never used in the red form above, as the action would be too vigorous, but is mixed with some of the black ore from previous anneals, in the proportion of one of red ore to four, five, six or seven parts of black ore. If the mixture is too rich, that is, contains too much red ore, the action is accelerated, the castings are apt to "peel," or the ore may fuse on to the surface of the casting. Peeling is when part of the outer surface of a casting strips off, and usually results in scrapping the casting. When the ore melts on to the casting it may be possible to remove it with a hammer and chisel, or it may be necessary to scrap the casting.

The stacks of annealing cans may be packed in position inside the oven, or may be packed on a platform and loaded into the furnace by some mechanical device. Lack of skill or thought on the part of the packer may result in a good casting being rendered useless by some of the causes given above, or by reason of distortion due to a stack collapsing during annealing.

When the furnace is fully charged, the door is bricked up with two or three bricks being left loose for removal as sight holes. The fire is then lit off, all the dampers left open, and the fire continually replenished as it burns down. During the first 36 hours the temperature should rise steadily until 960 to 970 deg. C. is reached. This temperature must not be attained too rapidly, as damage may occur to the castings if heated too quickly, but should be reached in not less than 40 hours after firing off. By manipulation of the dampers the heat should be distributed over the entire oven, and the temperature is maintained during the day time as near to 960 deg. C. as possible. During the night the temperature may fall somewhat, but no harm will result provided the fall is not more than 120 deg. C., and the higher temperature is reached again during the early morning. This treatment is maintained for a further period of not less than 96 hours, when the furnace is allowed to cool off slowly, with the damper closed, until the temperature is in the neighbourhood of 700 deg C. This should take 24 to 26 hours, after which the damper is opened, the front doors opened, and the temperature allowed to fall more rapidly. It will be seen that the annealing is in three stages, a heating-up period of approximately 40 hrs., a maintenance of heat during 96 to 100 hrs., and a slow-cooling period of 24 to 26 hrs, that is to say, a total period of seven days from lighting off to unloading. Annealing ovens are costly to build, the fuel and labour charges are high, and for proper control require suitable pyrometers with recording charts.

In the author's works he always places in the front of each furnace a small box with a test-sample packed in ore. Whilst the oven is cooling down, one or two bricks are removed and this test-sample withdrawn. The sample is tested for ductility and fracture, and, if satisfactory, the stacks of pans can be removed. If any fault is found with the test-sample, suitable steps can be taken either to give the furnace a further firing period or to make additional tests as the work is knocked out. As a further precaution a test-sample is placed in the bottom can in each stack, and these are broken and examined before the stack is passed over to the fettling shop. The stacks are pulled over, the work removed from the one, and if the annealing has been satisfactory, the castings should have a blue or grey sheen, and be free from adhering sand or annealing ore. They are sent into the sand-blast room, thoroughly cleaned, and then passed on to fettling, final examination and despatch. The minimum time taken from when the pattern enters the foundry until the casting is despatched is nine days. On production work the average time is eighteen days, and it will be seen from the foregoing that a casting has to pass through many hands and many processes in its journey.

DISCUSSION.

Before the reading of the Paper, MR. C. GRESTY (Branch-President) stated that in asking Mr. F. H. Hurren to give a Paper on malleable iron, the Secretary had explained to him that the district was not one where malleable iron was produced, and therefore a Paper of an educational nature was what they required. Mr. Hurren would show them the differences in practice between malleable iron and ordinary iron.

At the conclusion of Mr. Hurren's Paper, MR. GRESTY, in opening the discussion, suggested that the annealing treatment brought its own group of troubles and that occasionally there were cases of heat distortion. Mr. Hurren had not mentioned what happened if a casting was distorted in annealing. He had several times said that it was cheaper to scrap the casting, but suppose the casting was urgently required, was there no treatment by which it could be corrected? It was bound to be an old idea, but, touching the question of composition, what was the great objection to using iron containing rather more silicon with a view to shortening the annealing time? Those cognisant of the effect of heat on cast iron knew that the silicon content was the chief factor. It might be, of course, that using high silicon led to rather rapid oxidation. Could not that, perhaps, be put right by suitably adjusting the oxide packing? Certainly the time taken for annealing was very long, and any alteration in the composition on those lines would make a saving of time. In dealing with mixtures, Mr. Hurren had stated that annealed scrap must not exceed 5 per cent., and he would like to know why. Supposing that he did put in 15 or 20 per cent., what would be the nature of the trouble he would expect? In the various castings with which he was dealing it would be very interesting to know what type of casting thickness Mr. Hurren referred to particularly. In dealing with very different thicknesses, was the composition altered or did the one composition do for all classes with just differences in the annealing treatment?

He asked Mr. Hurren if he had tried any of the heat-resisting steels for annealing cans, as no doubt the annealing cans were very greatly affected by heat, or was the cost too great for the length of life of the heat-resisting steel compared with the life of the ordinary white iron annealing cans? What was the ordinary length of life of a white iron annealing can?

Setting Distorted Castings.

MR. HURREN, replying to Mr. Gresty, said that it was possible to reset castings which had been badly distorted during annealing. It was very often easier to reset such a casting cold, but one had to bear in mind that to get a permanent set on a casting it had to be stressed beyond its elastic limit. Therefore, if much distortion had occurred, the casting would be considerably weakened by being set cold. If a casting was heated to a very bright red heat and there were suitable dies made to take the size of the casting it could easily be set, but the cooling down would have to be very slow, lasting over a period of twenty-four hours, otherwise the casting would be unmachinable. Mr. Gresty's question as to whether the annealing time could be shortened by increasing the silicon content was a very pertinent one. It had been found, however, that by increasing the silicon one ran the risk of getting a grey fracture in the hard casting. When it was annealed it would be even more grey. Any area that was grey in the hard casting would be soft but quite brittle, and would have no elongation or bend; it would be practically heat-treated cast iron. If the silicon could be increased without that risk, the time of annealing could be reduced. It was possible that developments on those lines might take place in the direction of chilled castings. Small castings which were suitable for casting in chills could be made in very much higher silicon content, up to 1.4 per cent., and still remain white in the hard state. After about a period of 60 hours' annealing, very good ductile malleable iron with a good tensile strength was obtained. The British Engineering Standards tensile strength of 20 tons was not difficult to obtain, the elongation, however, was harder.

Thick and Thin Sections.

With regard to Mr. Gresty's question as to why it was not a good policy to use too much annealed scrap, it was for the reasons he had just mentioned. The annealed scrap contained free carbon which, on melting, although many authorities say it is dissolved and becomes combined carbon, persists, and is shown as free carbon in the fracture of the casting. If there were free carbon in the hard casting, a good casting would not be obtained on annealing. With reference to the question of thickness, there were various thicknesses. If some castings were of heavy section, ¾ to 1 in. thick, and others only ¼ or ⅜ in. thick, it was quite easy to arrange them in ovens in what are known as the hot or cold parts of the oven. Some castings were, unfortunately, thick in one part and thin in others. In such a case one had to anneal so that the thick sections would be soft and machinable and the thin sections would not be over-annealed. The strength of the ore during packing had to be varied, *i.e.*, slightly stronger ore round the thick sections, and in that way one could overcome those difficulties.

Life of Cans.

With reference to the use of heat-resisting steels for annealing cans, it was questionable how long cans made of such steel would last. The cost at the present time was definitely prohibitive. They had to carry a stock of 25 to 30 tons of annealing cans, and he had just been figuring out that for heat-resisting steel annealing cans there would be an outlay of £10,000, and until heat-resisting cans could be bought at about £8 or £10 per ton, it

was out of the question to use them. The ordinary annealing cans were usually made of a mixture of white malleable pig, soft annealed scrap, and a little hematite pig for strengthening purposes. The life of one of those cans, if used with reasonable care, was at a maximum, seven heats, *i.e.*, seven times in the oven. By then they were scaled until they were so thin that there was a danger of their collapsing or of the actual flame penetrating the wall of the can and scaling the casting. In his own works they now daubed the cans with a mixture of fireclay, ganister and dust, which increased the life of the cans to about twelve heats, and it had shown a very considerable saving.

MR. A. LOGAN said that Mr. Hurren had mentioned the figures of 20 tons tensile and 5 per cent. elongation in connection with mechanical tests. He would like to know what the permissible limits on those figures were. Assuming one of the test pieces, which Mr. Hurren had stated were put into the ovens, only gave 18 tons tensile test, would that reject the whole batch? With regard to the question of mixtures, Mr. Hurren had said that he preferred one brand of pig-iron. Had he any particular reason for that preference, and did it in any way influence the product? Why should not more than 10 per cent. steel be added? What was the temperature of the castings when they were removed from the mould, and were they rather fragile at that temperature? Was it necessary that the fracture of a casting should be completely white? He would like to know what limits there were in that respect. Must the total carbon be completely combined or was a small percentage of graphitic carbon permissible, and what was the limit, if any? He did not think the lecturer had made it quite clear whether he was dealing with black heart or white heart malleable iron. Which was the better process or were they each good for particular kinds of work?

Specifications.

MR. HURREN, referring to Mr. Logan's question about the limits on the mechanical tests, said that the British Engineering Standards Association laid down various mechanical tests, those being—tensile strength of 20 tons per sq. in., elongation of 5 per cent. on 2 in., and tested in the "as cast" condition, *i.e.*, without machining. Also, there was a bend test on a bar 8 in. long, 1 in. wide and ¾ in. thick, the edges of which could be slightly round, and which should give a test not less than 45 deg. on 1-in. radius. For those standards, a tensile and a bend test-piece for every ton of castings were required, and alternative test-bars if one should fail. There was no difficulty in obtaining the tensile strength, but there was difficulty in getting the elongation, and there might be difficulty with the bend test. Five per cent. elongation could only be obtained after the castings were properly and thoroughly annealed. If the elongation test failed, the bend test generally failed also. In that case, if the second test-bar also gave low results, those castings were open to rejection, but at the same time it might be possible to give them a further annealing. In connection with his preference for one brand of pig-iron, most malleable pig-iron was made on the North-East Coast and some on the West. He did not know why, but it was a peculiar thing that East Coast and West Coast iron would not mix to give a homogeneous mixture. Whether there was a difference in the temperature of melting or not he could not say, but when they had two different pigs in the cupola charge there were always certain castings for that day giving free carbon in the hard state. It was not only his own experience, but the experience of others that this phenomenon took place. If there was free carbon in the hard casting in small areas, those areas remain as free carbon after annealing, and the carbon becomes oxidised, or there would be a growth of carbon in that small area, which becomes a black patch, which shows up distinctly during machining. After machining, any free carbon that has been in the hard casting always shows up black. The reason why it was not feasible to have more than 10 per cent. steel addition was because steel reduced the degree of superheat of the molten metal. When heavy steel additions were made there was always liable to be sluggish taps, and the metal might be dull and pasty. The only reason for adding any steel to the iron was to reduce the total carbon in the mixture. The total carbon could reach 4 per cent. maximum. The best test-results were obtained when the total carbon was between 2.9 and 3.1 per cent. As the pig-iron contained nearly 4 per cent., the usual method for reducing it was by steel additions, but there was always the danger of getting dull iron. The castings were, of course, more fragile when they were hot than when they were cold, although in many instances the castings were as fragile when they were cold. There was not much danger of breakages when removing the casting from the mould, and if Mr. Logan had seen some of the workmen throwing the castings from one end of the shop to the other he would think they were made of steel. There was always a risk when knocking out of getting a casting cracked.

With reference to the fracture of a casting as cast, it ought to be white. There was very little danger of finding a fracture on the thin section other than white. In the thick sections there was sometimes a slight amount of free carbon deposited during cooling. It gave rise to the danger that after annealing areas of free carbon would enlarge and give spongy patches. If an amount of free carbon kept in the centre of a large section where the machining would not reveal it, there was not a great deal of danger from it. The percentage of free carbon in an annealed casting depended to a large extent on the thickness of the casting. On the thin sections it could be as low as 0.2 or 0.3 per cent., while the thick sections of a properly-annealed casting should not contain more than 1.3 or 1.4 per cent. What was really of more importance was the relation between the free carbon and the combined carbon, which to give the best results ought to be equal parts of both.

White-Heart only Considered.

He ought to have explained at the beginning of his Paper that he was speaking entirely on the subject of white-heart malleable iron, and as he had only been interested in white heart, he was not able to say which was really the better process. Each had its particular advantages and disadvantages. There was one main disadvantage of black heart, after a heavy machining the tough carbon free skin on the casting was sometimes removed entirely, and therefore the weaker core of the casting only comes into service. On the other hand, if white-heart castings are only turned on the outside and not sufficiently annealed, the annealed portion would be machined off and the remainder of the castings would be white and hard, and instead of having weak cores they would have very hard ones.

MR. PAULIN said there was one thing to be said for malleable iron and that was that one could obtain a much neater job than could be obtained from cast steel; he supposed that one could also get a thinner section in malleable iron. Mr. Hurren had mentioned that it took about as much again as the casting itself in the shape of headers to produce a sound casting and yet he only used 10 per cent. of that scrap. He would like to know what he did with the remainder. Did he use chills very much for heavy sections? It would be possible to use pieces of iron to fill in the spaces so that the metal running in would melt and fuse it as was done, he believed, in steel castings. Mr. Hurren had also stated that hardness was sometimes set up during the fettling operations, and he could not understand that. Could it not be overcome during the annealing? He had said that a blast of 12 ozs. was the common pressure, and that a higher blast resulted in a loss of silicon. Was not that rather an excessive pressure from the modern viewpoint? Comparing it with ordinary cupola practice in grey iron, it seemed very high. The amount of silicon would be very much lower indeed than that in a similar thickness in grey iron. He would like to know if in malleable iron, when a flaw occurred which might be a material flaw, they had any process, such as welding as used for steel upon which they could depend.

MR. HURREN said that there were certain advantages which malleable iron had over steel. He had always maintained that true malleable iron could not be obtained in sections over ¾ in. thick. Above that thickness it was a compromise, but with a thickness of ¾ in. or less there ought to be no difficulty in obtaining a soft, easily machinable and ductile casting. Malleable castings were also made in very small sections, and there were numerous small castings made which it would be impossible to make in steel owing to the fineness of the section. He knew of one shop which made malleable castings of which it took four gross to make one pound in weight. Mr. Paulin must have misunderstood him about the amount of scrap used on a charge in way of feeders and runners. He had simply said that the amount of feeders and runners must bear certain relation to the amount of pig, so that the calculated percentage of silicon was 0.75 per cent. before melting. As a matter of fact, it was quite a common thing for the runners and feeders to be approximately half the total charge, and if a charge, say, in their own works where they used an 8-cwt. charge, they would take four hundred pounds of runners and feeders and then certain proportions of pig and 10 per cent. of annealed scrap or steel. If the runners and feeders were not used up in that way they would get such a stack in the yard that they would have no room for anything else. Referring to the fact that chills were not much used in malleable iron and to Mr. Paulin's suggestion that pieces of iron be put in the heavy sections to melt up when the metal was poured, it was an idea which had never occurred to him in connection with malleable iron, and when he returned to the works he was going to try it out.

Fettling in the Hard State.

Most of the fettling was done after the castings were annealed. It had been tried by grinding in the hard state, but there was only one firm in England which employed that method successfully. It required a considerable amount of skill. If the castings were fettled in the hard state there was three times as much wear on the grinding wheel, and owing to the heat set up, small incipient cracks appeared in the casting which extended during annealing, therefore, it was safer to fettle after annealing. It was only surface hardness that was caused during the fettling, and it could easily be overcome by putting the castings in an ordinary muffle furnace for a few hours, the temperature being somewhere between 800 and 900 deg. C. Mr. Paulin had queried the blast pressure. He agreed it was rather on the high side, but had always found that one obtained quicker melting and hotter iron even at the risk of slightly increased loss of silicon. The average loss of silicon was about 0.17 per cent., whatever the calculated silicon was in the charge, and if the silicon was low that was any amount to one-quarter or nearly one-third of the total silicon in the mixture. Welding up a flaw in malleable castings was possible if done with care, and the castings were given a subsequent heat treatment for a few hours at about 900 deg., followed by slow cooling. Welding should only be practised on malleable iron when the casting had been previously heated. If one attempted to weld a casting which was cold there was always the danger that after it was welded up fine cracks would start somewhere else.

Carbon Reduction by Steel Additions.

MR. MOLINEUX said that one point which had interested him was that Mr. Hurren had stated that he could get carbon down from 4 to 2.9 per cent. with the addition of 10 per cent. of steel, which seemed rather extraordinary. With regard to the comparison of white-heart malleable and black-heart malleable iron, he had had a rough idea that one of the advantages of white-heart iron was that one could make light castings comparatively cheaply, but the thicker sections could be more readily made in black-heart iron, due to the differences in the two processes. In the white-heart process the limit of ¾ in. was due to the fact that somehow the carbon was extracted from the section, which would be difficult to do in a section over that thickness.

MR. HURREN replied that he hoped that he had not led anyone to think that he could reduce 4 per cent. carbon to 2.9 per cent. with an addition of 10 per cent. of steel. What he really wished to convey was that if the carbon in the pig was high it might be necessary to use steel in the charge to bring the total carbon down to as low as it was possible to get it. When the

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total carbon in the pig was high it was not policy to use too much pig in the charge, but if a small percentage of pig was used a much larger percentage of scrap and runners, and then a steel addition was needed. They would find that by calculation they could bring the total carbon in the mixture down to 3.3 per cent. He might say that pigs with a total carbon of 4 per cent. were not common, the average being a maximum total carbon somewhere in the neighbourhood of 3.4 per cent. There was one particular pig on the market in which the total carbon was between 3.8 and 4 per cent., and small percentages of it could be used with safety if the high carbon was counteracted by a steel addition. In that particular case the pig was not used alone, but in conjunction with other pigs lower in total carbon. Mr. Molineux had stated the differences between the uses of white-heart and black-heart malleable iron. For small, thin sections white heart was undoubtedly unequalled, but in heavy sections it was probable that black heart was the better material to use.

Mr. V. Stobie asked Mr. Hurren what he considered was the lowest carbon which could be usefully used, and Mr. Hurren replied that up to about three years ago the actual effect of carbon on the annealing was only vaguely understood. The British Cast Iron Research Association undertook a long and comprehensive research on the subject, and found that the best all-round results were obtained when the total carbon in the hard casting was between 2.9 and 3.1 per cent. The usual malleable-iron pigs which were on the market contained somewhere round about those figures, the usual percentage being between 3 and 3.3 per cent. In white-heart malleable it had been discovered that if the total carbon was reduced under certain circumstances, the time of annealing could be reduced to get results which compared very favourably with iron annealed by ordinary practice. The difficulties of reducing the carbon were far greater than the difficulties of annealing. That was to say that unless some manufacturer could come along with a low-carbon iron which he would be prepared to guarantee as to the limits of carbon, one could not commercially anneal differently for different carbons. That was that once an oven was packed it was only possible to carry out the annealing for the average conditions of the castings in the oven. If it was possible to reduce the time of annealing by reducing the total carbon, it could only be done if the whole of the work which was put in the oven was of low total carbon. He would like to say that until the British Cast Iron Research Association undertook about three or four years ago a series of researches on white-heart iron, what they thought they knew before were merely surmises, and that now they had something really definite to work upon. He thought it was a great credit to the Association to have done those researches, and in that connection the Institute of British Foundrymen instigated the formation of the British Cast Iron Research Association.

Mr. Kirby asked if oil-sand cores were used for malleable work. Mr. Hurren said that a certain amount were used, and that they could be made in exactly the same way as for grey iron, and, moreover, wherever possible they used such cores and found them very effective. The sand for the moulds was an ordinary facing of black and red sand with coal dust.

Mr. A. Logan proposed a vote of thanks to Mr. Hurren for his lecture, which he said had been greatly appreciated by them, as had been shown by the discussion. The lecture had not been long, but it had been very complete, and Mr. Hurren had been very painstaking in his replies to their questions. Mr. V. Stobie seconded, and Mr. Hurren suitably replied.

A record for the Workington Prince of Wales' dock was set up in the week ended Friday last by the loading into various vessels of 10,000 tons of steel rails. The imports of foreign iron ore at the Prince of Wales' dock, for the last quarter of the year, amounted to 30,850 tons, compared with 24,480 tons for the previous three months, and 19,400 tons in the corresponding period of last year. The imports of ore for December were 18,600 tons, against 12,250 tons for November, and 8,200 tons in December, 1927.

Application of Electro-Deposited Metals to Engineering.

In the course of a Paper read on the "Application of Electro-Deposited Metals to Engineering" by Mr. C. H. Faris, A.M.I.Mech.E., before the Institution of Engineering Inspection, the author pointed out that the art of imposing upon the surface of a metal a coating of a different metal had long been known as plating, but as such coatings were usually exceedingly thin, and were not sufficiently intimately associated with the base, or underlying metal, to justify their safe use on engineering work, or on components forming an integral part of any important mechanism, the work never found acceptance by engineers as a recognised shop method. For ornamental or decorative purposes such plating had its legitimate scope, but if in time the absence of adhesion resulted in the flaking or peeling of the coating the consequences were not disastrous, and replating could easily be done. If such flaking of a deposit occurred on a vital part such as a crankshaft, or a machine-tool part, the resultant trouble might be serious; hence the unreliability, due to the absence of adhesion, precluded the entry of such work into the domain of mechanical engineering.

In all the many and varied branches of the engineering industry (continued the author) expensive parts are regularly scrapped through being undersize, due to either wear, corrosion or machining errors. The methods of salvage hitherto employed on material falling into the above categories are too numerous and familiar to need mention, but it is safe to say that welding would claim quite a fair share. In many cases welding may prove satisfactory, but drawbacks exist which become particularly undesirable, especially on malleable iron or specially heat-treated steel work. Take, for example, a malleable-iron casting in the form of a housing which is too large to suit the ball-bearing intended to fit in the bore, or an automobile engine crankshaft, which may be from 0.020 in. to 0.040 in. down on diameter on the throw pins or main journals. Welding on either of those jobs would be somewhat of a risk, but they could be dealt with in an ideal manner by the cold process of nickel deposition.

Wear Resistance.

Until the entry of nickel into the field of engineering repairs, the metal had rarely been used, as a pure metal, for bearing surfaces or engineering parts. Figures are not yet available, but it is known that the co-efficient of friction of the nickel is lower than that of steel, under similar conditions. As bearing somewhat upon the question of wearing properties, a few particulars may here be inserted concerning the metal itself. The anodes from which the deposits are made are of 99.9 per cent. purity, the specific gravity of the pure nickel is 8.8, and the melting point is 1,452 deg. C., or 2,646 deg. Fah. The highest recorded Brinell hardness number, obtained at the National Physical Laboratory, was 377, the average figure reached on the bulk of work being treated would be in the region of 350. With the Herbert pendulum hardness tester an average of 30 is maintained, but readings have been taken at 35, and it is expected that subsequent tests will reveal that nickel possesses the quality of work-hardening to an appreciable degree.

Corrosion affects many industries, and the matter is receiving most careful thought and study, by those competent to deal with it, particularly in the case of parts exposed to sea water, superheated steam, etc. Alloys appear to yield to the corrosive agent more readily than a pure metal, so that it would be reasonable to suggest that if a metal be found resistant to the particular corrosive action being dealt with at the moment, the parts involved would be more lasting if protected by a coating of such metal. Just as in the case of heavy deposits for building up worn parts, so the lighter deposits for this protective work require to be unstrippable, absolutely adherent and amalgamated with the underlying metal.

Applicability of Nickel.

For contact with foodstuffs no better metal can be found than nickel, whilst as a protection against sea water the metal proves quite satisfactory. A steel specimen coated with nickel was suspended in the Firth of Tay, just off Dundee, at half tide, for nine months, after which, on inspection, it was found to be unaffected. The author again saw it removed after a further period of twelve months, and it was still sound. The test was not only a prolonged one but exceedingly severe.

The first portion of the Paper reviews electro-depositing mainly on steel and cast-iron parts, but case-hardened and tempered steel, and those steels which form the "stainless" group, may also be built up when worn by slightly different treatment. Heavy and unstrippable deposits of nickel may also be imposed upon the bronzes, copper, and aluminium, but in such cases the resultant work is greatly dependent upon the soundness and quality of the metal under treatment. In all cases of deposition good sound metal is essential if perfect adhesion is to be obtained, therefore, spongy patches, or blowholes in castings, cannot be wholly cured, yet are often improved by the treatment.

Other metals are deposited in addition to nickel, such as copper, cadmium, cobalt, lead and chromium. Nickel is the more extensively used because of its remarkable wearing property, its immunity from corrosion and the comparative ease with which the deposits are produced. Cadmium is found to be a good preservative against the effects of sea water and other forms of corrosion, where no hard wear is encountered, but, owing to the softness of the metal, it is not recommended as a wearing surface. Chromium is being used to a much greater extent, not only for decorative purposes, but for engineering work, one particularly interesting job being the building up with that metal of worn plug gauges, which are not only exceedingly hard, but resistant to corrosion.

The subsequent machining of the parts built up with nickel does not present any special difficulty providing that care is exercised to avoid crowding on the cut too much, and the correct cutting and clearance angles are observed. Where possible grinding is resorted to on diameters and bores as a better finish is obtainable and it is more economical in expenditure of time.

Contracts Open.

Blackburn, January 12.—Iron castings and iron and steel stores, etc., for the Corporation. Mr. H. M. Webb, borough and water engineer, Town Hall, Blackburn.

Cairo, February 5.—Steel squares, rounds, flats and plates, for the Egyptian State Railways. The Chief Inspecting Engineer, 41, Tothill Street, London, S.W.1.

Liverpool, January 17.—Steel sheets, files, iron castings, etc., for the Corporation. The General Manager, Corporation Tramways, 24, Hatton Garden, Liverpool.

London, N.1, January 18.—Iron and steel stores, for the Islington Borough Council. Mr. C. G. E. Fletcher, town clerk, Municipal Buildings, Upper Street, N.1.

London, N.W., January 21.—Supply and erection of wrought-iron railings and chain-link wire fencing, for the Hendon Urban District Council. Mr. A. O. Knight, engineer and surveyor, Town Hall, Hendon, N.W.4.

London, S.E., January 18.—Steel axles and tyres, for the India Store Department, Belvedere Road, Lambeth, London, S.E.1. (Fee 5s., non-returnable.)

London, S.E., January 15-22.—Five tons of copper and brass sheets, and 21 tons of antimony, for the India Store Department, Belvedere Road, Lambeth, London, S.E.1. (Fee 5s., non-returnable.)

Wigton, January 21.—65 miles of cast-iron pipes, 7 in., 5 in., 4 in., 3 in. and 2 in. diam., for the Rural District Council. Messrs. Taylor & Wallin, 1, Saville Place, Newcastle-on-Tyne. (Fee £10, returnable.)

Winnipeg.—675 tons of steel bars, for a local firm. The Department of Overseas Trade. (Reference A.X. 7309.)

Messrs. William Beardmore & Company, Limited, Glasgow, are reported to have received an order from the Indian State Railway for 44 locomotives.

Shrinkage Holes in Small Grey Iron Castings.

(*Continued from page* 28.)

the chills out whilst the mould was still red or after stripping? His (Mr. Bacon's) experience was that if they were left in overnight the casting was in such condition in the centre that it could not be machined with the best tool steel. He thought it was best to knock out the chills whilst the mould was still red.

MR. RUSSELL, replying, said he never removed taper chills hot if he could avoid it. He always left them in if possible, and he had never had a failure by the casting becoming unmachineable, except in one exceptional circumstance.

The CHAIRMAN (Mr. Thornton) said the discussion had been most interesting, but he doubted whether any discussion could get far without first knowing all the facts of the particular castings under consideration. Without that knowledge of all facts, the discussion was bound, to some extent, to go round in a ring. They did not know Mr. Russell's casting temperature, his velocity, whether his sand was wet or dry, and other factors which all had an important bearing on the finished product. Special mention had been made of Mr. Russell's analyses of iron as shown on the screen, and it had seemed to him (Mr. Thornton), as it obviously had seemed to other speakers, that the analyses were unsuitable. They had, of course, had the lecturer's explanation of those analyses. Personally, said Mr. Thornton, he thought one could usually obtain the analysis one required for the particular class of casting quite as cheaply as Mr. Russell was producing. One mentioned 10 per cent. of steel, but he had cast up to 50 per cent., and this for castings which had to be machined and have a very high polish. If there are available two or three brands of pig-iron and various scrap, one can arrange the mixtures with a little addition of steel very cheaply and probably save on the amount of risers added. If the cupola conditions were right there was no such thing as "semi-steel." One put steel into the cupola and it came out cast iron. Mr. Thornton said he was sure Mr. Russell had done extremely well and had been very courageous in tackling such a subject in the bold way he had done, and the members were certainly grateful to him for a most valuable contribution to their transactions.

Vote of Thanks.

MR. W. H. POOLE (Keighley), moving a vote of thanks to Mr. Russell for his Paper, remarked that if Mr. Russell had mentioned at the outset that the bulk of his analyses as given in the Paper were rather different from his usual practice he would have saved himself much criticism. He (Mr. Poole) felt pretty sure that Mr. Russell was not running that particular type of mixture as a regular practice. He was very bold to bring forward a topic of this nature before a gathering of practical men, and the branch had every reason to be indebted to him for a lecture, the discussion on which had possibly brought out some points which were as interesting to the lecturer as to his hearers.

MR. A. S. WORCESTER, seconding, mentioned that Mr. Russell's Paper had been awarded a diploma at the last Convention. It was the kind of Paper which the practical man badly needed. Personally, ever since Mr. Russell's Paper was published in THE FOUNDRY TRADE JOURNAL he had kept it by him as a standard work of reference.

MR. RUSSELL, replying to the vote of thanks, said he thought the Chairman had been hardly fair to him in introducing his criticism after the discussion was closed. It was perfectly true that not all the analyses given on the slides were analyses in normal practice. He would not be prepared to work generally with such analyses, and he had introduced them deliberately as striking and interesting examples for study.

THE AYRESOME IRON WORKS, Middlesbrough, relighted two of their blast furnaces on January 3, after nine months idleness

Copper and Its Alloys.

A meeting of the London Junior Section of the Institute of British Foundrymen was held at the Offices of THE FOUNDRY TRADE JOURNAL recently. Mr. F. Cummings (Chairman) presided over a good attendance.

A Paper entitled, "Copper and Its Alloys," was read by Mr. L. H. Howell. The author commenced his Paper with a historical review of the subject, pointing out that copper was found in its native state in many parts of the world, and especially notable was that obtained from the Lake Superior district and Chili. The copper obtained from Chili was found in what was called copper-sand or copper-barilla, namely, grains of quartz admixed. The largest proportion of copper came from its mineral state, and ores were mined, smelted and refined to allow the foundryman to melt and collect as many of the impurities as he felt disposed.

The lecturer then dealt with the properties of copper, dealing with the reasons for the variations of fracture. The refining process, poling (for the liberation of oxygen), etc., were touched upon. Speaking of the effect of heat-treatment, he said that copper was malleable cold and at a red heat, but became brittle on nearing the temperature at which it melted. The ductility lost during rolling might be restored by annealing.

Effect of Impurities.

In the form of cuprous oxide (11.2 per cent. oxygen) dissolved in liquid copper, but it was not very soluble in the solid state. The presence of oxygen both in molten and solid copper tended to make the metal brittle. Silicon was taken up in copper to the extent of 5 per cent., and was a useful deoxidiser when the electrical conductivity was to be kept at the maximum.

Lead would not alloy with copper, and on solidification lead was found in globules around the copper crystals. The eutectic contained 0.1 per cent. copper (melting point 364 deg. C.). Phosphorus was often used as a deoxidising agent; 0.08 per cent. of this element reduced the electrical conductivity by half. Bismuth was the most injurious impurity as regards strength. It was soluble in the liquid but not in the solid state. Even a very minute quantity would have a drastic embrittling effect, as the bismuth solidified in films between the crystals.

Arsenic had a very deleterious effect upon the electrical conductivity. Small quantities up to 0.5 per cent. were used to increase the tenacity, the fullest advantage being gained when the metal was heated above normal temperature. Antimony had a more drastic effect upon the electrical conductivity than arsenic, although the presence of oxygen modified this. Antimony was also detrimental to the proper working of copper. Selenium and tellurium both conducted electricity, although one form of selenium was practically non-conductive, probably their presence was due to their being found in pyrites in the ore.

Casting.

Copper was one of the most difficult metals to cast successfully and soundly, owing to the liberation of gas on solidification. Small quantities of zinc or phosphorus were often added, but for electrical purposes these lowered the conductivity too much for consideration.

Alloys of Copper.

The addition of zinc to copper resulted in the well-known alloys, the brasses. These were often classified by the proportion of copper to zinc, for example 70/30 and 60/40, the major portion being copper in both cases. On adding zinc to copper solid solutions were formed. These were known as alpha, beta, and gamma solid solutions, and when polished and etched they might be determined under a high-power microscope. There was a correlation between the microstructure and the mechanical properties. The tensile strength increased with the zinc content until 41.5 per cent. zinc was reached. The elongation reached a maximum about 29 per cent. zinc, and fell rapidly on adding more zinc.

Mechanical Treatment.

Alloys containing alpha only were specially suitable for cold working, but might be rolled hot or cold. Those containing alpha and beta were difficult to roll cold, and might only be rolled hot; all beta alloys might be rolled, forged or extruded hot, whilst gamma alloys were too brittle to be worked.

Impurities.

Lead was often added to brass to improve its machineability, but it should not exceed 0.1 per cent. A brass containing 2-3 per cent. of lead would break with a grey fracture. Lead did not alloy with brass, and under the microscope appeared in globular form. Tin was added to harden the alloy, and to withstand sea-water attack. When more than 2 per cent. was added it had an embrittling effect. Iron had the effect of hardening brasses; being soluble up to 2 per cent., whilst above this figure iron-zinc compounds were formed. Arsenic, antimony and bismuth, all had an embrittling effect, making the brass liable to crack on rolling.

In making manganese brass, crucible furnaces were often employed, although coke-fired tilting furnaces and gas-fired furnaces were far more efficient. For large castings, weighing over a ton, the metal was usually ingotted first and then charged into a reverberatory furnace and remelted. Aluminium, manganese, tin, etc., besides strengthening the alloys had the power to replace zinc. To obtain high tensile strengths when the metal was in the beta condition, it was often preferable to add 1 to 2 per cent. of aluminium or manganese instead of adding more zinc. Care should be taken to keep the tin content down to 2 per cent., as 1 per cent. tin is equivalent to 2 per cent. zinc (approx.).

An interesting discussion followed, at the conclusion of which Mr. V. C. Faulkner (Past-President of the Institute) proposed a vote of thanks to the lecturer, which was seconded by Mr. Cummings.

Light Castings Trade Dispute.

Wages Cut Protest.

As the result of a wages dispute which has arisen in the light castings industry, strike action has been decided upon by the foundry workers affected. Since the month of May the scale of wages in the industry has been the subject of almost constant discussion and negotiation between the National Light Castings Federation and the Joint Committee of the various Trade Unions. Agreement was finally reached on a general reduction, which was given effect to early in September, notwithstanding that a ballot vote of the men went overwhelmingly against the acceptance of it. The new trouble has arisen in connection with the rates of men employed in the production of rain-water goods. Notices were posted at the foundries prior to the commencement of the New Year holiday that a 5 per cent. reduction on the bonus payable to rain-water moulders would be made as from January 1, but, of course, the holiday extended to January 7.

A largely attended meeting of the affected men was held in the Town Hall, Falkirk, on January 3, when the whole position was reviewed, and a resolution was carried declaring a strike, but it is understood that, provided the workers in the other Scottish districts and in England agree, a further ballot vote will be taken to determine future action. If the ballot is agreed to, the result cannot be known until January 12, so that the men will remain on strike for at least a fortnight. Throughout England and Scotland about 3,000 men will be affected by the strike, and of these about one-third are in the Falkirk area.

Diaries, &c., Received.

We have received from the **Clay Cross Company, Limited**, a neat waistcoat-pocket diary, which contains a fund of technical data, and describes and illustrates the firm's works and products.

Trade Talk.

A FALL FROM A ladder at the foundry of Messrs. Aiton & Company, Derby, resulted in the death of Charles James Alton, aged 35, a labourer.

EMPLOYERS IN THE Belgian iron and steel industry have decided to grant an increase in their workmen's pay of one franc a day, to begin on January 15.

MESSRS. BETTENCOURT & COMPANY, iron, steel and tinplate merchants, have removed their offices to Post Office Chambers, 26, Brown Street, Manchester.

MESSRS. ALEXANDER STEPHENS & SONS, Linthouse, have received an order from Messrs. Maclay & Macintyre, of Glasgow, to build a cargo vessel of 9,000 tons deadweight.

THE Crown Agents for the Colonies have placed an order with Messrs. Hurst Nelson & Company, Limited, Motherwell, for 45 bogie wagons for the Ceylon Government railways.

A NEW forging department, which is being built at the works of the Chillington Tool Company, Limited, Wolverhampton, is expected to be completed and in operation in a few weeks' time.

MESSRS. BLACKSTONE & COMPANY, LIMITED, Stamford, have received from the Jersey Granite and Concrete Company, Limited, of Jersey, orders for the installation of Blackstone spring-injection heavy-oil engines.

THE CONTRACT for the new Lambeth Bridge to be built across the Thames for the London County Council in place of the old suspension bridge has been secured by Messrs. Dorman, Long & Company, Limited, Middlesbrough.

THE DIRECTORS of the London and North-Eastern Railway have authorised the construction of 110 new locomotives, all of which, with the exception of twenty shunting engines, will be constructed in the L.N.E.R. shops during 1929.

THE CANADIAN PACIFIC RAILWAY COMPANY have placed an order with the Fairfield Shipbuilding and Engineering Company, Limited, Glasgow, for two passenger steamers for service at Vancouver. The value of the contract is £500,000.

A MOST ENJOYABLE social was promoted by the Derby members of the Association of Engineers and Shipbuilding Draughtsmen on New Year's Eve, at St. James's Restaurant. There was a company of 80, who, after dinner, danced the Old Year out and the New Year in.

IT IS officially stated that plans for the final reconstruction of Messrs. Sir W. G. Armstrong, Whitworth & Company, Limited, are well advanced, and that in all probability a scheme will be laid before all classes of debenture holders, note-holders and shareholders in the very near future.

MESSRS. BOW, M'LACHLAN & COMPANY, LIMITED, Paisley, have received an order for a passenger and cargo steamer for the Bombay Steam Navigation Company. The vessel will be about 1,185 tons gross, and have engines of 1,730 i.h.p., and similar to the "Kalavati" built last year for the same owners.

THE COWPEN DRY DOCKS AND SHIPBUILDING COMPANY, LIMITED, Blyth, launched during 1928, five vessels, totalling 29,102 gross tons, with engines of 8,650 i.h.p., supplied by Messrs. Blair & Company (1926), Limited, Stockton-on-Tees. The iron and brass foundries belonging to the company have also been well employed.

MESSRS. JOHN G. KINCAID & COMPANY, LIMITED, Greenock, were busy during the past year with the construction of Diesel engines on the Burmeister & Wain principle, 14 sets of these engines having been constructed by them. Twelve sets of steam engines have also been completed, giving the firm a total output for the year of 90,783 i.h.p.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, and the Electric Furnace Company, Limited (who are sole licensees for the British Ajax-Northrup patents), have entered into an agreement whereby each company has the right to manufacture and supply coreless induction furnaces incorporating the Ajax-Northrup and Metropolitan-Vickers patents.

DURING LAST YEAR Messrs. Vickers-Armstrongs, Limited, launched six warships from their Naval Construction Works at Barrow-in-Furness. They have in hand four submarines and a destroyer for the British Navy, two submarines for the Chilean Navy, two pairs of dock gates for the new Bromborough Dock of Messrs. Lever Brothers, Limited, and a 20,000-ton liner for the Orient Steam Navigation Company.

ACCORDING TO a Spanish paper, the well-known Skoda Works have purchased a large site in Spain on which to construct works to meet the Spanish demand for steel. The paper states that the output of the company's works in Czecho-Slovakia is booked up for the next five years, and that, as they are concentrating their attention on the British market in competition with Germany, the company are starting a new enterprise abroad so as to have a freer hand.

A CONTRACT HAS BEEN SIGNED between Messrs. Sir W. G. Armstrong, Whitworth and Company, Limited, and the Chilian Naval Commission in London, for the construction of two oil tank steamers of a special type, which will be laid down at the Walker Shipyard, Newcastle-on-Tyne. Messrs. Armstrong, Whitworth and Company are pioneers in the construction of oil tank steamers. This latest contract will bring the number of vessels of this class built by the firm to 161.

WHEN KING AMANULLAH visited Sheffield he took great interest in the steelmaking processes and the engineering works. Later a Sheffield firm of engineers, who specialise in the construction of electric furnaces for the making of steel and the melting and refining of metals, received an order for an electric furnace to be despatched to Afghanistan. The order has been completed and the furnace sent to Kabul, where, it is understood, it will be utilised in the melting of brass.

THE GRINDING AND PULVERISING OFFICES of International Combustion, Limited, 11, Southampton Row, London, W.C.1, report that orders have recently been received for the following equipment:—For England: One 3 ft. by 5 ft. two-surface Hum-mer screen, for screening slag; one 3 ft. by 2½ ft. one-surface Hum-mer screen, for screening limestone; one 3 ft. by 5 ft. one-surface Hum-mer screen, for screening iron and mixture of iron and zinc shavings; and one 3 ft. by 18 ft. Hardinge mill, with classifier, for grinding glass frit. For Australia: Three 8 ft. and two 4 ft. by 5 ft. one-surface Hum-mer screens, for screening lead-zinc ore. For France: One 4½ ft. by 22 in. Hardinge mill, for grinding lead compound; one 4½ ft. by 36 in. Hardinge mill, for grinding calcined flint; one 3 ft. by 24 in. Hardinge mill; one five-roller and two four-roller Raymond mills, for grinding coal; one Raymond pulveriser, for grinding copper hydrate; one Raymond pulveriser, for grinding carbonate of magnesia; and two 3-ft. Raymond separators.

THE YEAR 1928 has been one of considerable activity in shipyards on Clydeside, the output being the largest since 1920. There were 229 vessels launched, representing a gross tonnage of 601,918, while the machinery constructed was equivalent to 705,762 i.h.p. as compared with 274 ships of 462,510 tons and 647,870 i.h.p. last year. The largest output on the river was that of Messrs. Lithgows, Limited, Port Glasgow, with 15 vessels of 80,027 tons. Messrs. John Brown & Company, Limited, Clydebank, were second with four vessels, of 78,117 tons. In engineering, the Fairfield Shipbuilding and Engineering Company, Limited, Govan, head the list with 111,200 i.h.p.

MESSRS. WILLIAMS & WILLIAMS, LIMITED, metal window makers, of Chester, have issued a circular to shareholders which states that an offer of 30s. per share for the 18,500 unissued ordinary shares and 27s. 6d. per share for 6,500 of the unissued preference shares has been accepted. The directors are desirous of taking up the remaining 13,500 preference shares at 27s. 6d. per share, but before doing so consider that these shares should be offered in the first instance to shareholders in proportion to their present holdings. Contracts have been secured during the past few months from the United States, Australia, South Africa, the Federated Malay States and India, and two bays have been added to the Chester Works to provide for an increased output.

ARISING OUT OF THE purchase by Messrs. Thos. W. Ward, Limited, Sheffield, of the Low Moor Ironworks and other properties, Mr. Ashley Ward, joint managing director, states that several sections of the enterprise will be developed. The foundry and engineering works, now closed, will probably be reopened, and two of the collieries, Beeston and Osmondthorpe, near Leeds, will be restarted. The blast-furnaces and engineering shops have been closed for some time. With regard to the firm's shipbreaking works at Morecambe, which the Morecambe Town Council thought might have to be closed because of alterations to be made to the pier on which they stand, Mr. Ward states that it is likely that these works will be continued as at present for another year, and then some arrangement may be reached with the Morecambe Corporation.

Obituary.

THE DEATH occurred on January 4, at Stirling, of Mr. James Davie, of Messrs. J. Davie & Sons, Limited, Ironfounders.

MR. JAMES T. DALY, who was managing director of the Horseley Bridge and Engineering Company, Limited, Tipton, died at Leamington recently, aged 75.

SIR CHARLES METCALFE, Bt., who died at his home at Godalming, on December 29, aged 75, had a long and distinguished career as a railway engineer in Rhodesia. His firm, Sir Douglas Fox & Partners, built the bridge over the Zambesi at Victoria Falls.

Personal.

MR. C. E. STRAW is retiring from the staff of Cammell, Laird's Cyclops Works, Sheffield, after 53 years' continuous service with the firm. He has been presented with a gold watch by his present-day colleagues at Cyclops works.

MR. C. C. DAVIDSON has retired after 49 years' service in connection with Lord Leconfield's iron-ore mines at Cleator Moor and Bigrigg, Cumberland, first as engineer and later as manager. Last week Mr. Davidson was the recipient of a presentation from the men employed at the mines.

AFTER serving as works manager at Messrs. Ransome & Marles & Company, Limited, for a period of ten years, Mr. J. D. Scaife has just retired from the position and is shortly to sail for America. He is well known to members of the foundry and engineering trades in Notts, and is a Past President of the Institute of Productive Engineers.

SIR CECIL L. BUDD is relinquishing the office of managing director of the British Metal Corporation, Limited, which he has held jointly with Captain Oliver Lyttelton. He will retain his seat on the board and will continue to act as chairman of the management committee. It is also announced that Sir Cecil Budd has resigned the chairmanship of the board of the London Metal Exchange, which he has held for over 26 years.

Wills.

JOHN ALEXANDER, of Alexander's Foundry Company, Barrhead	£9,226
WOOTTON, W. H., of Victoria Street, Loughborough, Leicester, retired brass-founder	£20,900
NAYLOR, J., of Christchurch Road, Norwich, engineers' tool maker, of Sheffield	£24,056
CHURCH, G. E. A., of Whalebone Lane, Chadwell Heath, Essex, and St. Mary-at-Hill, E.C., oxide of iron merchant...	£12,925
SANSOM, H., late of Messrs. Sansom Brothers & Company, Mansfield, Notts, ironfounder	£8,467
HASSALL, JOHN, J.P., of Rotherwood, Ashby-de-la-Zouch, of Messrs. John Knowles & Company, Limited, sanitary pipe manufacturers, Burton-on-Trent...	£55,147
HOLLINGWORTH, S., of Gowan Lea, Mountjoy Road, Huddersfield, a director of the Hygienic Stove Company, iron founders	£30,571

Reports and Dividends.

Baker, Perkins, Limited.—Interim dividend of 4 per cent., less tax, on the ordinary shares.

Allen-Liversidge, Limited.—Interim dividend on the ordinary shares of 5 per cent. (actual), less tax.

Westinghouse Brake & Saxby Signal Company, Limited.—Net profit, £144,883; brought in, £7,582; to depreciation reserve, £7,000; to general reserve, £20,000; dividend of 10 per cent., less tax; carried forward, £13,228.

Channel Steel Company, Limited.—The capital account has been increased by a call of 3d. per share on the partly-paid preferred ordinary shares. The directors have been unable to take any steps towards proceeding with the development of the company's properties. The liquidation of Kent Collieries, Limited, has been closed, and the cash in hand at the close of liquidation has been paid to the company. The electrical plant at Shakespeare Colliery having become obsolete, it has been disposed of, together with surplus plant and materials.

Applications for Trade Marks.

The following applications to register trade marks are extracted from the "Trade Marks Journal":—

"COANAILIUM."—Aluminium alloy castings, metal in ingots, drawn and sheet metal. Robert William Coan, Limited, Duncan Street, London, N.1.

"GOAHED."—Steel. Thomas Millington & Company, Limited, 79-80, Weaman Street, Birmingham.

"TACTIC" and "TOTEM."—Metals. Hall & Pickles, Limited, 43, Arundel Street, Sheffield.

"ATECOR."—Metals. John Brown & Company, Limited, Atlas Steel and Iron Works, Sheffield

"ROTOKAST."—Metals. The British Piston Ring Company, Limited, Holbrook Lane, Coventry.

"KYMORE." — Wire. The Kymore Syndicate, Limited, Balfour House, Finsbury Pavement, London, E.C.2.

"TORILLO."—Steel wire. Hicks, Monro & Company, 50, High Street, Addlestone.

TEAM BY-PRODUCT COKE CO., LTD.

DUNSTON-on-TYNE

"TEAM" PATENT COKE

SPECIAL FOUNDRY QUALITY

FOR PRICE AND PARTICULARS APPLY TO:—

ALEXANDER LEITH & CO.,
25, COLLINGWOOD STREET,
NEWCASTLE-ON-TYNE.

TYPICAL ANALYSIS (if necessary guaranteed)

ASH	not exceeding	8%
SULPHUR	,, ,,	0·8%
VOLATILE	,, ,,	1 %
MOISTURE	under	1·50%

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,

FIRE CLAY.

Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

STEEL MOULDERS' COMPOSITION, SILICA CEMENT.

J. GRAYSON LOWOOD & CO., LTD.

DEEPCAR, nr. SHEFFIELD.

Telegrams: "LOWOOD, DEEPCAR."

WARNER'S CYLINDER PIG IRON

BRAND "WARNER C.E.R."

THE WORLD'S BEST

WARNER & CO. LTD.

CARGO FLEET,
MIDDLESBROUGH ON TEES.

As supplied to the leading....
RAILWAY COMPANIES, LOCOMOTIVE, DIESEL and OIL ENGINE BUILDERS.
Also unequalled for
AUTOMOBILE CYLINDER BLOCKS, COMPRESSORS, ENGINEERS' TOUGH CASTINGS and CHILLED ROLLS.

TELEGRAMS:
REFINERY MIDDLESBROUGH.

ALSO MAKERS OF
HIGH CLASS REFINED PIG IRON
IN SMALL PIGS, FOR ALL KINDS OF
MALLEABLE CASTINGS

TELEPHONE:
MIDDLESBROUGH 4265.

Iron and Steel Markets.

Pig-Iron.

MIDDLESBROUGH.—After practically an entire cessation of actual business for the past fortnight the usual Cleveland iron markets were resumed this week with a fair attendance of representatives of both consuming and producing interests, mainly intent on discussing the prospects and possibilities of the industry during the coming season. That the future is now regarded with more assured confidence is expressed in the opinions stated by the most eminent authorities in the trade, including Sir Arthur Dorman, for example, who declares: "I think we have seen the worst of the long depression in the iron and coal trades, and I am convinced that we can now look forward hopefully to a period of steady improvement." Sir Hugh Bell, Bt., affirms that: "Although I do not dream rosy dreams of an Eldorado just round the corner, I retain my confidence in the future of the important industries of the North-East"; whilst Sir Holberry Mensforth, managing director of Messrs. Bolckow, Vaughan & Company, Limited, expresses the view that: "The outlook for the New Year is bright, and I believe that there will be an appreciable improvement in trade during 1929." It is, of course, as yet, too early to forecast how far these heartening opinions will be justified by results, but, at all events, it is something distinctly to the good to learn that men qualified by expert knowledge and experience now hold such optimistic views in cheerful contrast to those mostly entertained by the trade during the dismal year just closed. At Tuesday's market the business transacted was chiefly confined to renewals of expiring contracts, but inquiries were also more in evidence, so that no difficulty will be experienced in disposing of surplus stocks accumulated during the holiday weeks. Meanwhile, quotations are maintained at the following levels, f.o.t. or f.o.b.:—No. 1 foundry iron, 68s. 6d. per ton; No. 3 G.M.B., 66s.; No. 4 foundry, 65s.; No. 4 forge, 64s. 6d. per ton.

Conditions in the East Coast hematite market continue the improvement previously noted, and production has already been increased to meet expanding demands. There is, however, no attempt made to force up the price level, and sellers are content to negotiate business on the basis of 71s. per ton for mixed numbers and 71s. 6d. for No. 1 quality, with concessions for big orders. On the North-West Coast prices are unchanged, Bessemer mixed numbers being quoted at 71s. per ton at works.

LANCASHIRE.—Markets for foundry pig in this area continue quiet for the time being, without price movements of outstanding importance requiring comment. Staffordshire brands are currently quoted at from 67s. to 67s. 6d. per ton, for delivery Manchester or equal distance, and Derbyshire makes at around 68s., or a few pence below this figure.

THE MIDLANDS.—Buying in the foundry iron market has been so long confined within such narrow limits that business can hardly be expected to develop on heavier lines immediately, but the tone at the Birmingham quarterly meeting was certainly more hopeful, although prices, so far, have been undisturbed. Nominal quotations remain steady at 55s. to 56s. for Northants. No. 3, 59s. to 60s. for Derbyshire No. 3, and 60s. for North Staffordshire No. 3.

SCOTLAND.—Throughout this area the foundries are still very slack, and while here and there consumers are inclined to buy a little ahead, generally speaking the demand is only for day-to-day requirements, and, unfortunately, there is no indication of any improvement in this direction. Prices are unchanged on the basis of 70s. for No. 3 Scotch foundry, f.o.t. furnaces.

Finished Iron.

The quarterly market at Birmingham this week had but poor encouragement for makers of this class of material, which remains only in moderate demand. There continues to be a paucity of orders for crown and the cheaper grades of iron, with insufficient business to keep the mills working at anything approaching full time, and there exists under such conditions intense competition between the local ironworks and those in Derbyshire and Lancashire. Crown iron is offered at between £9 and £9 5s., and nut and bolt iron at £8 12s. 6d. and upwards.

Scrap.

With the advent of the New Year consumers of foundry scrap metals are coming into the various markets for fresh supplies, and on Tees-side the likelihood of higher values for heavy cast iron is now freely suggested, but at present it is still possible to purchase ordinary quality at 60s. per ton and machinery quality at 65s., delivered works. In the Midlands also there is a fairly good demand for cast-iron scrap; 65s. delivered is offered for machinery cast-iron scrap broken into cupola sizes, and 55s. for light cast-iron scrap. In Scotland machinery cast-iron scrap shows no change at 65s. to 66s., and for heavy ordinary cast-iron scrap, suitable for foundries, 60s. to 61s. is quoted. Old cast-iron railway chairs are at 64s. to 65s. There is no change in light cast-iron scrap at 58s. The above prices are all per ton, delivered f.o.t. consumers' works.

Steel.

Conditions in most branches of the steel industry have not yet become definitely settled down to normal activity, but the outlook is very distinctly brighter than at this period last year, and with a substantial increase in shipyard contracts the tone of markets is certainly more cheerful. The Continental position is being watched with interest by buyers in this country. There has been little inclination shown, however, to enter into contracts, and as a consequence Continental steel prices developed an easier tendency. Within the past few days a somewhat firmer tone has been noticeable. If trade develops in the way that is anticipated, the position in this market might easily change, and prices again advance. The tone of the tinplate market is quite good, with quotations ranging around 18s. to 18s. 1½d. basis for coke qualities in approved specifications, net cash, f.o.b. Welsh ports.

Metals.

Copper.—The maintenance of steady values of warrant copper is continued, consumers doubtless influenced by the not unlikely prospect of a rise in prices, having been buying on a large scale. This particularly applies to consumers both on the Continent and in America. This large increase in consumptive demand has undoubtedly been considerably aided by fears, which are entertained at the moment, of a temporary shortage of blister copper on account of the damage caused by the recent earthquake in the region of the Braden mines, causing some dislocation of South American transport.

Closing quotations are:—

Cash.—Thursday, £74 5s. to £74 7s. 6d.; Friday, £74 13s. 9d. to £74 15s.; Monday, £74 10s. to £74 12s. 6d.; Tuesday, £74 5s. to £74 7s. 6d.; Wednesday, £75 to £75 2s. 6d.

Three Months.—Thursday, £73 2s. 6d. to £73 5s.; Friday, £73 7s. 6d. to £73 8s. 9d.; Monday, £73 2s. 6d. to £73 5s.; Tuesday, £73 to £73 1s. 3d.; Wednesday, £73 7s. 6d. to £73 10s.

Tin.—Consumptive inquiries, both in this country and on the Continent, still continue slow, but American advices report a fairly good demand. Although it is difficult to estimate to what extent consumers there may have already purchased their supplies, it is quite within the bounds of possibility that further buying might easily develop soon, which could not be without its response from this market.

Official closing prices:—

Cash.—Thursday, £222 to £222 5s.; Friday, £220 10s. to £220 15s.; Monday, £223 to £223 5s.; Tuesday, £226 to £226 5s.; Wednesday, £226 2s. 6d. to £226 5s.

Three Months.—Thursday, £222 10s. to £222 15s.; Friday, £220 10s. to £220 15s.; Monday, £222 15s. to £223; Tuesday, £225 10s. to £225 15s.; Wednesday, £225 to £225 5s.

Spelter.—The position in this section of the market remains practically the same fundamentally. Trade with consumers has been quiet, as was only to be expected. No further light has as yet been thrown upon the agreement reported to have been reached by producers in Brussels a few weeks ago.

Daily quotations are:—

Ordinary.—Thursday, £26 8s. 9d.; Friday, £26 1s. 3d.; Monday, £26 2s. 6d.; Tuesday, £26 7s. 6d.; Wednesday, £26 12s. 6d.

Lead.—Arrivals of soft foreign pig continue to be more than ample to meet present requirements, and the market, although seasonably quiet, is very steady and firm in tone. With regard to the future, reports from the Continent and the United States are optimistic, so that, with the turn of the year, there is every possibility of a resumption of consuming interest, which may also bring about a rise in values.

Prices have been:—

Soft Foreign Prompt.—Thursday, £22 3s. 9d.; Friday, £21 18s. 9d.; Monday, £22 1s. 3d.; Tuesday, £22 2s. 6d.; Wednesday, £22 1s. 3d.

November Metal Statistics.

Lead.

TOTAL STOCKS in Metal Exchange warehouses, 400 tons.

IMPORTS into the United Kingdom during the month: From Australia, 6,571 tons; Africa, nil; Burma, 2,075 tons; Canada, 3,821 tons; other Dominions, 18 tons; United States, 5,450 tons; Mexico, 70; Spain, 1,129 tons; Germany, 48 tons; miscellaneous, 17 tons.

EXPORTS during the month: To British Dominions, 174 tons; Europe, 860 tons; other countries, 123 tons.

APPARENT CONSUMPTION of imported pig lead, 18,317 tons.

RECEIPTS into warehouse during the month, 123 tons.

DELIVERIES from warehouse during the month, 398 tons.

SHIPMENTS during the month: From Australia to U.K. and Continent, 14,069 tons; from Africa and Burma to U.K., 3,850 tons; from Africa and Burma to all countries, 2,050 tons.

Spelter.

TOTAL STOCKS in Metal Exchange warehouses, 1,486 tons.

IMPORTS into the U.K. during the month: From Canada, 655 tons; all other Dominions, 839 tons; U.S.A., 2,370 tons; Belgium, 5,479 tons; Poland, 450 tons; Scandinavia, 250 tons; Germany, 2,450 tons; other European countries, 633 tons; miscellaneous, 127 tons.

EXPORTS during the month: To the Dominions, 470 tons; Europe, 167 tons; other countries, 3 tons.

RECEIPTS into warehouse during the month, 2,055 tons.

DELIVERIES from warehouse during the month, 1,240 tons.

Copper.

TOTAL STOCKS in Metal Exchange warehouses, 6,935 tons.

IMPORTS into the United Kingdom during the month: From the British Empire, 1,657 tons; United States, 6,992 tons; Chile, 3,981 tons; Africa, 138 tons; miscellaneous, 934 tons.

EXPORTS during the month: To British Dominions, 31 tons; Europe, 980 tons; other countries, 42 tons.

RECEIPTS into warehouse during the month, 910 tons.

DELIVERIES from warehouse during the month, 2,572 tons.

SHIPMENTS during the month: From Chile to U.K., 3,400 tons; from Chile to Germany, 2,015 tons; from Chile to U.S.A., 17,445 tons; from Chile to France, 2,155 tons; from Chile to Italy, 1,360 tons; from Chile to all other countries, 2,075 tons; from Australia to all destinations, nil; from Africa to U.K., 473 tons; from Africa to Continent, 5,713 tons; from Africa to U.S.A., 1,937 tons.

New Companies.

Henry Richmond & Sons, Limited.—Capital £100. Malleable ironfounders, etc. Director: A. E. Archer, 112, Duchy Road, Harrogate.

Richard Ashton & Company, Limited, 36, Cheapside, Birmingham.—Capital £6,000. Malleable ironfounders. Directors: W. E., W. H., and T. W. Bond.

Marshall Bros. (Birmingham), Limited, 288, Icknield Street, Birmingham.—Capital £10,000. General brassfounders, etc. Directors: W. Davis and J. S. Davis.

R. Jones & Company (1928), Limited, Stone Yard, Deritend, Birmingham.—Capital £30,000. Tin smelters and solder manufacturers. Directors: A. E. Smith and S. Smith.

Thornton Norris Products, Limited.—Capital £1,000 in 1s. shares. Metallurgists, ironfounders, etc. Directors: G. Thornton Norris, 42, Wymering Mansions, London, W.; C. Gardner and I. H. Abelson.

Sterling

SOLID RIBBED ROLLED STEEL

MOULDING BOXES

are recognised as Standard Box equipment by the majority of the leading foundries and engineering establishments in this country and overseas.

Because they speed up production, save unnecessary labour, produce accurate castings and make for all-round efficiency.

If you are not a user of Sterling Boxes your competitors have the advantage of you.

STERLING FOUNDRY SPECIALTIES LTD.

London Office:
13, VICTORIA STREET, S.W.1.

BEDFORD.

Telephone : 3345 BEDFORD.
Telegrams : "STERFLASK, BEDFORD."
Code WESTERN UNION.

WEEKLY PRICE CURRENT.

COPPER.

	£ s. d.
Standard cash	75 0 0
Three months	73 7 6
Electrolytic	78 5 0
Tough	76 0 0
Best selected	76 10 0
Sheets	102 0 0
India	86 15 0
Wire bars	78 12 6
Do. January	78 12 6
Do. February	78 12 6
Ingot bars	78 12 6
H.C. Wire rods	82 15 0
Off. av. cash, December	69 7 7 3/8
Do. 3 mths., December	69 4 4 1/2
Do., Sttlmnt., December	69 7 7 1/8
Do., Electro, December	75 4 10 5/8
Do., B.S., December	73 16 10 1/2
Aver. spot price, copper, Dec.	69 7 7 3/8
Do. Wire bars, December	75 9 8 1/2
Solid drawn tubes	14 1/2d.
Brazed tubes	14 1/2d.
Wire	10 1/4d.

BRASS.

Solid drawn tubes	12 1/2d.
Brazed tubes	14 1/2d.
Rods, drawn	11 1/2d.
Rods, extd. or rlld.	7 1/2d.
Sheets to 10 w.g.	10 3/4d.
Wire	10 1/2d.
Rolled metal	10 1/2d
Yellow metal rods	7 1/2d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets	8 1/2d.

TIN.

	£ s. d.
Standard cash	226 2 6
Three months	225 0 0
English	225 15 0
Bars	227 15 0
Straits	227 5 0
Australian	226 5 0
Eastern	227 10 0
Banca	227 0 0
Off. av. cash, December	227 13 11 7/10
Do., 3 mths., December	226 8 3 9/10
Do., Sttlmt., December	227 12 10 1/2
Aver. spot, December	227 13 11 7/10

SPELTER.

	£ s. d.
Ordinary	26 12 6
Remelted	25 0 0
Hard	20 0 0
Electro 99.9	29 10 0
English	26 15 0
India	21 15 0
Zinc dust (Nom.)	36 10 0
Zinc ashes	8 5 0
Off. aver., December	26 12 2 1/2
Aver., spot, December	26 12 2 1/2

LEAD.

	£ s. d.
Soft foreign ppt.	22 1 3
English	23 10 0
Off. average, December	21 10 8 1/2
Average spot, December	21 6 10 7/10

ZINC SHEETS, &c.

	£ s. d.
Zinc sheets, English	35 0 0
Do. V.M. ex whf.	33 10 0
Rods	44 0 0
Boiler plates	32 0 0
Battery plates	33 0 0

ANTIMONY.

	£ s. d.
Special brands, Eng.	54 10 0
Chinese	38 0 0
Crude	33 10 0

QUICKSILVER.

	£ s. d.
Quicksilver	22 5 9

FERRO-ALLOYS AND STEEL-MAKING METALS.

	£ s. d.
Ferro-silicon—	
25%	7 17 6
45/50%	12 0 0
75%	19 0 0
Ferro-vanadium—	
35/50%	14/- lb. Va.
Ferro-molybdenum—	
70/75% c. free	4/3 lb. Mo.
Ferro-titanium—	
23/25% carbonless	1/- lb.
Ferro-phosphorus, 20/25%	£18 0 0
Ferro-tungsten—	
80/85%, c. fr.	1/5 lb.
Tungsten metal powder—	
98/99%	1/10 lb.
Ferro-chrome—	
2/4% car.	£30 0 0
4/6% car.	£21 12 6
6/8% car.	£20 12 6
8/10% car.	£20 10 0
Ferro-chrome—	
Max. 2% car.	£33 0 0
Max. 1% car.	£37 0 0
Max. 0.70% car.	£44 0 0
70%, carbonless	1/- lb.
Nickel—99%, cubes or pellets	£175 0 0
Ferro-cobalt	9/- lb.
Aluminium 98 99%	£95 0 0
Metallic chromium—	
96/98%	2/6 lb.
Ferro-manganese (net)—	
76/80% loose	£13 15 0
76/80% packed	£14 15 0
76/80%, export	£14 10 0
Metallic manganese—	
94/96%, carbonless	1/6 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	£0 2 3
Finished bars, 18% tungsten	£0 2 9

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under 1/2 in. to 1/4 in.	3d. lb.
Do., under 1/4 in. to 1/8 in.	1/- lb.
Flats, 1/2 in. × 1/4 in. to under 1 in. × 1/8 in.	3d. lb.
Do., under 1/4 in. × 1/4 in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

Scrap from high-speed tool steel—	
Scrap pieces	3d.
Turnings and swarf	1d.

Per lb. net, d/d steel makers' works.

SCRAP.

	£ s. d.	£ s. d.
South Wales—		
Hvy. steel	3 8 6	to 3 10 0
Bundled steel and shrngs.	3 4 0	to 3 8 6
Mixed iron and steel	3 3 0	to 3 4 0
Heavy cast iron	2 16 0	to 2 18 0
Good machinery for foundries	2 18 0	to 3 0 0
Cleveland—		
Heavy steel		3 0 0
Steel turnings		2 8 0
Cast iron borings		2 3 0
Heavy forge		3 7 6
Bushelled scrap		2 18 6
Cast-iron scrap		3 2 6
Lancashire—		
Cast-iron scrap	2 15 0	to 3 5 0
Hvy. wrought		3 7 6
Steel turnings		2 5 0

London—Merchants' buying prices delivered yard.

	£ s. d.
Copper (clean)	57 0 0
Brass	39 0 0
Lead (less usual draft)	19 10 0
Tea lead	16 10 0
Zinc	17 0 0
New aluminium cuttings	67 0 0
Braziery copper	52 0 0
Gunmetal	50 0 0
Hollow pewter	150 0 0
Shaped black pewter	105 0 0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	68/6
Foundry No. 3	66/-
Foundry No. 4	65/-
Forge No. 4	64/6
Hematite No. 1	71/6
Hematite M/Nos.	71/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	78/-
,, d/d Birm.	85/6
Midlands—	
Staffs. common*	67/6
,, No. 4 forge	56/-
,, No. 3 fdry.	60/-
Shrops. basic	—
,, Cold blast, ord.*	—
,, ,, roll iron*	—
* d/d Birmingham.	
Northants forge	52/-
,, fdry. No. 3	55/-
Derbyshire forge	59/-
,, fdry. No. 3	60/-
,, basic	65/-
Scotland—	
Foundry No. 1	75/-
,, No. 3	70/-
Hem. M/Nos.	75/-
Sheffield (d/d district)—	
Derby forge	61/6
,, fdry. No. 3	64/-
Lincs. forge	62/6
,, fdry. No. 3	65/6
E.C. hematite	81/-
W.C. hematite	82/6
Lincs. (at furnaces)—	
Forge No. 4	58/-
Foundry No. 3	61/-
Basic	60/-
Lancashire (d/d eq. Man.)—	
Derby forge	—
,, fdry. No. 3	67/6
Northants foundry No. 3	—
Dalzell, No. 3(special)	100/- to 102/6
Summerlee, No. 3	87/6 to 90/-
Glengarnock, No. 3	87/6 to 90/-
Gartsherrie, No. 3	87/6 to 90/-
Monkland, No. 3	87/6 to 90/-
Shotts, No. 3	87/6 to 90/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.) nom.		10 5 0
Nut and bolt iron	8 12 6	to 8 17 6
Hoops		11 10 0
Marked bars (Staffs.) f.o.t.		12 0 0
Gas strip		11 10 0
Bolts and nuts, 1/2 in. × 4 in.		15 5 0
Steel—		
Ship plates	8 7 6	to 8 12 6
Boiler plts.		10 10 0
Chequer plts.		10 12 6
Angles		7 17 6
Tees		8 17 6
Joists		7 17 6
Rounds and squares, 3 in. to 5 1/2 in.		8 17 6
Rounds under 3 in. to 1/4 in. (Untested)		7 15 0 and upwards
Flats, over 5 in. wide and up		8 7 6
Flats, 5 in. to 1 1/2 in.		7 17 6
Rails, heavy		8 10 0
Fishplates		12 10 0
Hoops (Staffs.)		10 10 0
Black sheets, 24g.	10 0 0	to 10 10 0
Galv. cor. shts. 24g.	13 7 6	to 13 12 6
Galv. fencing wire 8g. plain		12 10 0
Billets, soft	6 5 0	to 6 12 6
Billets, hard	7 0 0	to 7 12 6
Sheet bars		6 0 0
Tin bars		6 0 0

PHOSPHOR BRONZE.

	Per lb. basis
Strip	1 3
Sheet to 10 w.g.	1 3 1/2
Wire	1 4 1/2
Rods	1 3 1/2
Tubes	1 8
Castings	1 2 1/2

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3 1/2 to 1/9 1/2
To 15 in. wide	1/3 1/2 to 1/9 1/2
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4 1/2 to 1/10 1/2
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5 1/2
Ingots rolled to spoon size	1/- to 1/8 1/2
Wire round—	
3/0 to 10 G.	1/6 1/2 to 2/1 1/2

with extras according to gauge.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	21.26
No. 2 foundry, Valley	18.00
No. 2 foundry, Birm.	16.50
Basic	19.26
Bessemer	20.79
Malleable	20.01
Grey forge	19.26
Ferro-mang. 80% d/d	105.00
O.-h. rails, h'y at mill	43.00
Bess billets	33.00
O.-h. billets	33.00
O.-h. sheet bars	33.00
Wire rods	42.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.95
Tank plates	1.90
Beams, etc.	1.90
Skelp, grooved steel	1.90
Skelp, sheared steel	1.90
Steel hoops	2.20
Sheets, black, No. 24	2.85
Sheets, galv., No. 24	3.60
Sheets, blue an'l'd, 9 and 10	2.10
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv.	3.30
Tinplates, 100 lb. box	$5.25

COKE (at ovens).

Welsh foundry	—
,, furnace	—
Durham and North.	
,, foundry	16/-
,, furnace	14/6
Midlands, foundry	—
,, ,, furnace	13/- to 14/6

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes	20×14 box	18/-
,,	28×20 ,,	36/-
,,	20×10 ,,	26/3
,,	18 3/4 × 14 ,,	18/9
C.W.	20×14 ,,	15/-
,,	28×20 ,,	33/6
,,	20×10 ,,	21/3
,,	18 3/4 × 14 ,,	15/-
Terneplates	28×20	33/6 per box basis f.o.b.

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6 0 0 to £7 10 0
Bars, hammered, basis	£17 10 0 to £18 10 0
Bars & nailrods, rolled, basis	£15 15 0 to £16 15 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£32 0 0 to £33 0 0
Faggot steel	£20 0 0 to £24 0 0
Bars & rods, dead soft, steel	£10 0 0 to £14 0 0

All per English ton, f.o.b. Gothenburg.

TUBES AND FITTINGS.
Up to and incl. 6 in.

	Tubes.	Fittings.
Gas	67½%	50%
Water	63¾%	45%
Steam	60%	40%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

			£	s.	d.		
Jan.	3	..	74	5	0	dec.	15/-
,,	4	..	74	13	9	inc.	8/9
,,	7	..	74	10	0	dec.	3/9
,,	8	..	74	5	0	,,	5/-
,,	9	..	75	0	0	inc.	15/-

Electrolytic Copper.

			£	s.	d.		
Jan.	3	..	78	5	0	inc.	20/-
,,	4	..	78	5	0	No change	
,,	7	..	78	5	0	,,	,,
,,	8	..	78	5	0	,,	,,
,,	9	..	78	5	0	,,	,,

Standard Tin (cash).

			£	s.	d.		
Jan.	3	..	222	0	0	dec.	70/-
,,	4	..	220	10	0	,,	30/-
,,	7	..	223	0	0	inc.	50/-
,,	8	..	226	0	0	,,	60/-
,,	9	..	226	2	6	,,	2/6

Tin (English ingots).

			£	s.	d.		
Jan.	3	..	222	0	0	dec.	70/-
,,	4	..	220	10	0	,,	30/-
,,	7	..	223	0	0	inc.	50/-
,,	8	..	225	15	0	,,	55/-
,,	9	..	225	15	0	No change	

Zinc Sheets (English).

			£	s.	d.		
Jan.	3	..	35	0	0	No change	
,,	4	..	35	0	0	,,	,,
,,	7	..	35	0	0	,,	,,
,,	8	..	35	0	0	,,	,,
,,	9	..	35	0	0	,,	,,

Spelter (ordinary).

			£	s.	d.		
Jan.	3	..	26	8	9	dec.	6/3
,,	4	..	26	1	3	,,	7/6
,,	7	..	26	2	6	inc.	1/3
,,	8	..	26	7	6	,,	5/-
,,	9	..	26	12	6	,,	5/-

Lead (English).

			£	s.	d.		
Jan.	3	..	23	10	0	No change	
,,	4	..	23	10	0	,,	,,
,,	7	..	23	10	0	,,	,,
,,	8	..	23	10	0	,,	,,
,,	9	..	23	10	0	,,	,,

AVERAGE MONTHLY PRICES OF UNMARKED BARS (SOUTH STAFFS).

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
1897	£ s. d. 6 0 0	£ s. d. 6 5 0	£ s. d. 6 5 0	£ s. d. 6 5 0	£ s. d. 6 5 0	£ s. d. 6 5 0	£ s. d. 6 5 0	£ s. d. 6 5 0	£ s. d. 6 5 0	£ s. d. 6 5 0	£ s. d. 6 0 0	£ s. d. 6 0 0	£ s. d. 6 3 9
98	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 5 0	6 5 0	6 5 0	6 10 0	6 10 0	6 2 11
99	6 10 0	6 15 0	6 15 0	7 0 0	7 0 0	7 0 0	7 10 0	7 10 0	8 10 0	9 0 0	9 0 0	9 10 0	7 12 11
00	10 0 0	10 10 0	10 10 0	10 10 0	10 15 0	10 15 0	10 5 0	10 5 0	10 5 0	9 10 0	8 15 0	8 15 0	10 1 3
01	8 0 0	7 10 0	7 5 0	7 0 0	6 10 0	6 10 0	6 10 0	6 10 0	6 15 0	6 15 0	6 15 0	6 15 0	6 17 11
902	7 0 0	6 10 0	6 15 0	6 15 0	6 15 0	6 10 0	6 10 0	6 15 0	6 15 0	6 15 0	6 10 0	6 10 9	6 13 4
903	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 7 0	6 5 0	6 9 4
904	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 5 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 2 11
905	6 5 0	6 5 0	6 0 0	5 17 6	5 15 0	5 15 0	5 15 0	6 0 0	6 0 0	6 5 0	6 15 0	6 15 0	6 1 10½
1906	7 0 0	7 5 0	7 5 0	7 5 0	6 17 6	6 15 0	6 12 6	6 10 0	6 10 0	6 12 6	6 16 3	7 3 9	6 17 8½
1907	7 3 9	7 5 0	7 5 0	7 5 0	7 5 0	7 7 6	7 5 0	7 7 6	7 7 6	7 7 6	7 7 6	7 5 0	7 5 11
1908	7 2 6	7 0 0	7 0 0	7 0 0	6 15 0	6 7 6	6 5 0	6 2 6	6 2 6	6 2 6	6 5 2 6	6 0 0	6 10 0
1909	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 2 6	6 2 6	5 17 6	5 19 9½
1910	6 2 6	6 3 4½	6 7 6	6 7 6	6 7 6	6 7 6	6 6 6	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 7
1911	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 12 6	6 16 6	6 7 0
1912	6 18 9	7 1 10	7 2 6	7 8 9	7 18 0	8 0 7	8 2 6	8 3 6	8 5 0	8 6 3	8 7 6	8 8 9	7 17 0
913	8 11 6	8 10 7½	8 10 0	8 8 1½	8 2 0	8 0 0	7 17 6	7 11 6	7 8 9	7 5 6	6 18 1½	6 17 6	7 16 9
914	6 17 6	6 15 7½	6 12 6	6 10 0	6 10 0	6 10 0	6 10 0	7 11 10½	8 0 0	7 12 6	7 5 7½	7 6 3	7 1 0
1915	7 11 6	8 5 11	8 8 9	9 6 0	10 3 2	10 19 2	11 12 6	11 13 1½	11 13 9	11 14 3	12 1 10½	13 0 9	10 6 0
1916	13 7 6	13 10 8	13 12 9½	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 3 9½
1917	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0
1918	13 15 0	13 17 3	13 17 6	13 17 6	13 17 6	13 17 6	13 17 6	14 15 0	14 15 0	14 15 0	14 15 0	14 15 0	14 4 5½
1919	15 10 0	16 5 0	17 15 0	17 15 0	20 15 0	21 0 0	21 0 0	22 0 0	22 0 0	22 0 0	22 7 6	22 12 6	20 1 8
1920	24 7 6	24 10 0	25 10 0	27 10 0	29 5 0	31 0 0	31 10 0	31 10 0	31 10 0	31 10 0	31 10 0	29 7 6	29 1 8
1921	26 17 3	25 0 0	23 0 0	21 0 0	19 0 0	18 5 0	16 0 0	16 0 0	15 14 0	14 0 0	13 6 8	13 0 0	19 4 5
1922	13 0 0	12 3 9	11 14 0	11 11 10½	11 5 0	11 3 6	11 2 6	11 5 0	10 17 2½	10 16 3	10 13 0	10 12 6	11 7 0½
1923	10 16 10½	11 3 1½	12 2 6	12 8 9	12 11 6	12 1 3	11 15 11½	11 15 0	11 15 0	11 15 0	12 13 6	12 8 3	11 18 10½
1924	12 9 6	12 10 0	12 10 0	12 15 7½	12 17 6	12 17 6	12 17 6	12 17 6	12 17 6	12 14 0	12 12 6	12 12 6	12 14 3½
1925	12 12 6	12 12 6	12 12 6	12 12 6	12 12 6	12 7 6	12 7 6	12 7 6	12 4 6	11 18 6	11 13 9	11 13 0	12 6 2½
1926	11 7 9½	11 5 0	11 5 0	11 5 0	11 3 9	11 3 9	11 5 0	12 0 0	13 0 0	*	15 7 6	12 19 0	12 0 2
1927	12 6 3	12 2 6	11 14 0	11 0 0	10 18 9	10 13 6	10 12 6	10 5 0	9 16 0	9 15 0	9 13 9	9 12 9	10 14 2
1928	9 12 6	9 12 6	9 11 0	9 10 0	9 8 4	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 3 6	9 1 3	£9 7 0

* No quotations available owing to strike.

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18, BENNETTS HILL, BIRMINGHAM.

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ZETLAND ROAD, MIDDLESBROUGH.

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(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED.

FOUNDRY FOREMAN seeks position; 24 years' sound practical experience, jobbing and repetition, modern plate and machine moulding methods, expert cupola practice; first-class references; would consider berth as Representative—Apply, Box 948, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

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A FOUNDRY IN SHROPSHIRE requires the services of an ASSISTANT to take responsibility ultimately for the technical side of Foundry work, including laboratory and mixtures, cupola control and experimental development. Applications will be considered from youths of 18 years or upwards who have been educated to matriculation standard, and laboratory or Foundry experience will be a recommendation. The wages paid will depend upon age and experience, and the successful candidate will be adequately trained for the work.

Applications will also be considered from those who have had a University course in Metallurgy, in which case the starting salary will be £150 per annum, or thereabouts, with facilities for learning the business.

Applications should give full details of education, training and experience, with copies of testimonials, before the 15th January, 1929, to Box 940, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

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PATENTS AND TRADE MARKS.

INFORMATION HANDBOOKS, Advice, and Cons. free; King's Patent Agency, Ltd.—B T. KING, C.I.M.E. (Regd. Pat. Agent, G.B., U.S.A., and Can.), 146A, Queen Victoria Street, E.C.4. 40 years' refs. 'Phone: 0682 Central.

THE owners of British Patents No. 193,401, Improvements relating to heating and smelting furnaces; No. 266,312, Process for the manufacture of girders and rails of broad flanged T and I Section: No. 264,468, Improvements in metallic sheet piling; and No. 283,914, for Improvements in wire reels, are desirous of entering into negotiations with one or more firms in Great Britain for the purpose of exploiting the inventions either by sale of the patent rights or by the grant of a licence or licences to manufacture on royalty.—Inquiries should be addressed to MESSRS. ABEL & IMRAY, 30, Southampton Buildings, London, W.C.2.

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FOUNDRY, adjoining station; equipped three tons daily; free now.—GIRLINGS, Maldon, Essex.

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5-TON OVERHEAD TRAVELLING CRANE. —Hand operated, double girder type, by MORRIS, two lifting speeds, gravity lowering, roller bearings, 40 ft. span.—For further particulars, etc., write Box 352, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

RICHARDS' No. 1 Vertical Slot Drilling and Keyway Cutting machine, capacity keyway 20 in. long x 1 in. wide.

36 in. centres "ASQUITH" Sliding and Surfacing Break Lathe, approximately 32 ft. between centres.

7-ft. Radial Arm Drilling Machine, by ASQUITH, 3½-in. balanced spindle.

32-in. Swing Vertical Boring and Turning Mill, by STIRK.

Two 6-WHEEL COUPLED SADDLE TANK STEAM LOCOMOTIVES (Andrew Barclay, Sons & Company, constructed 1924), having outside cylinders 12 in. dia. x 20 in. stroke. 160 lbs. W.P.

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One 4-WHEEL COUPLED SADDLE TANK STEAM LOCOMOTIVE (Barclays), having outside cylinders 14 in. dia. x 22 in. stroke. 150 lbs. W.P.

Two LANCASHIRE BOILERS, 30 ft. x 8 ft., reinsure 110 lbs. pressure.

One VERTICAL COCHRAN BOILER, 11 ft. 3 in. high x 5 ft. dia., reinsure 150 lbs. pressure.

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ONE 18"×18" Tabor Split pattern ..	£70
Two 40"×30" Tabor Shockless rollover	£160 each
12" Shockless plain jolter, 72"×60" table	£140
Two Bonvillain machines (24" dia. boxes)	£120
Four No. 0 Britannia jolters	£20 each
One 24"×48" Tabor Shockless rollover	£140
One 18"×36" Tabor Shockless rollover	£110
Twelve Adaptable Moulding Machines	£16 each

ALL ABOVE IN PERFECT ORDER.

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